SEPTEMBER, 1959
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FT food technology

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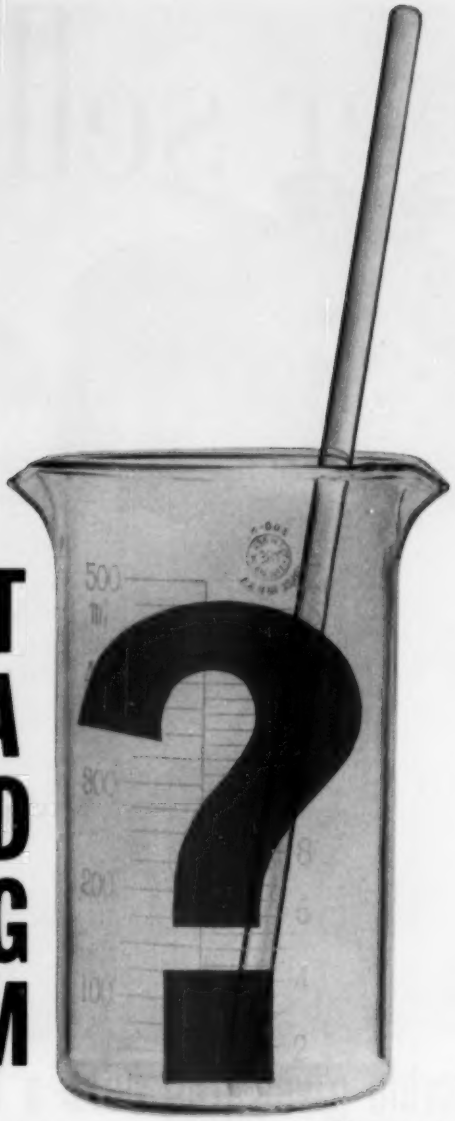

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FT food technology

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CONTENTS

Time-Temperature Tolerance of Frozen Foods. XIX. Ready-to-Cook Cut-up Chicken 477
A. A. KLOSE, M. F. POOL, A. A. CAMPBELL, AND H. L. HANSON

Control of Exudation in Prepeeled French-Fry Potatoes with Antibiotics 485
F. J. FRANCIS, B. L. AMLA AND A. KIRATSOUS

Effect of Sugar, Storage Time and Temperature on Dill Pickle Quality 489
ROSE MARIE PANGBORN, REESE H. VAUGHN, GEORGE K. YORK II, AND MARLENE ESTELLE

Interrelationships of Subjective, Chemical, and Sensory Evaluations of Beef Quality 492
D. H. KROPF AND R. L. GRAF

Pectin Standardization
Final Report of the IFT Committee 496

Some Factors Influencing Radiation Induced Chemical Changes in Raw Beef 501
O. F. BATZER, R. A. SLIWINSKI, LUCY CHANG, KATHERINE PIH, J. B. FOX, JR., D. M. DOTY, A. M. PEARSON, AND MILDRED E. SPOONER

The Influence of Sodium Chloride on Toxin Production and Organoleptic Breakdown in Perishable Cured Meat Inoculated with *Clostridium Botulinum* 509
RICHARD A. GREENBERG, JOHN H. SILLIKER, AND LOUIS D. FATTA

Use of Coating Materials or Film Impregnated with Chlortetracycline to Enhance Color and Storage Life of Fresh Beef 512
JOHN C. AYRES

Consumer Preferences for Beef of Different Breeds Related to Carcass and to Quality Grades 516
MARILYN DUNSING

Effect of Storage and of Cooking on Chlortetracycline Residues in Meat 520
OFELIA I. ESCANILLA, AGNES FRANCES CARLIN, AND JOHN C. AYRES

The Effect of Forty-three Years of Storage on Strawberry Preserves 525
GIDEON E. LIVINGSTON AND CHEE TECK TAN

Light Destruction of Riboflavin in Partially-baked Rolls 527
LOIS CARTER STEPHENS AND MARIAN FAULKNER CHASTAIN

A Comparison of the Methods for Applying Acronize Chlortetracycline to Beef 529
M. C. FIRMAN, H. J. BACHMANN, F. J. HEYRICH, AND P. F. HOPPER

Prevention of Darkening in Frozen Broilers 533
CORDELIA ELLIS AND J. G. WOODROOF

Notes and Letters

Effect of Illumination on Color of Frozen Peas Packaged in a Transparent Film 539
ALLAN D. SHEPHERD

Nominations Now Open for Food Technology's Industrial Achievement Award 20

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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Freezing technology *Ready-to-cook chicken*

Time-temperature tolerance of frozen foods. XIX. Ready-to-cook cut-up chicken. A. A. Klose, M. F. Pool, A. A. Campbell, and H. L. Hanson.

Frozen-storage tests were carried out on 2 commercial packs of cut-up chicken fryers differing in type and adequacy of package, one experimental pack of cut-up fryers in tin cans, and one commercial pack of cut-up stewing chickens. Evaluations were made of moisture loss, peroxide development, off odors in raw meat, and off flavors in cooked product. Slight off odor in thawed raw meat was the first quality defect detectable, followed by off flavors in cooked products. Chickens from all packaging conditions had a high-quality storage life of at least 6 months at 0° F. However, there were large differences in stability between the 2 commercial packs of fryers. They were to a great extent reflections of the large difference in package permeability. Chickens in the more permeable package had less than one-third the storage life of chickens in the less permeable package. Stewing hens held in a package of permeability intermediate between that of the 2 fryer packages had a corresponding intermediate storage life. Peroxide development in fat of stewing hens was correlated with the level of organoleptic deterioration. A storage test of cut-up fryers in tin cans with controlled atmospheres was used to establish independently the deteriorative effects of oxygen (air) availability and moisture loss. Moisture loss in itself was found to have little effect on organoleptic deterioration or chemical changes involving oxygen consumption. Access to oxygen of the air, on the other hand, contributed as much to rate of deterioration as a substantial rise in temperature. Appreciable deterioration and carbon dioxide production in nitrogen packs indicated that anaerobic reactions are also involved. Tests at +20°, +10°, 0°, −10°, and −30° F. provided evidence to support a recommendation for storage at 0° F. or below. Storage life at +20° F. ranged from less than one month to 6 months for the various packaging conditions, at +10° F. from 3 to 10 months, while at 0° F. storage life was at least 6 months in the poorest package and about 2 years in the best package. Within reasonable storage periods, a series of temperature fluctuations had practically the same (only slightly greater) deteriorative effect on quality as a steady temperature equal to the arithmetic mean of all of the fluctuations. The results emphasize that statements on storage life, to have real value, must accurately define the intimate product environment as governed by packaging as well as by temperature conditions. (See page 477).

Antibiotic treatment *French-fry potatoes*

Control of exudation in prepeeled French-Fry potatoes with antibiotics. F. J. Francis, B. L. Amla, and A. Kiratsous.

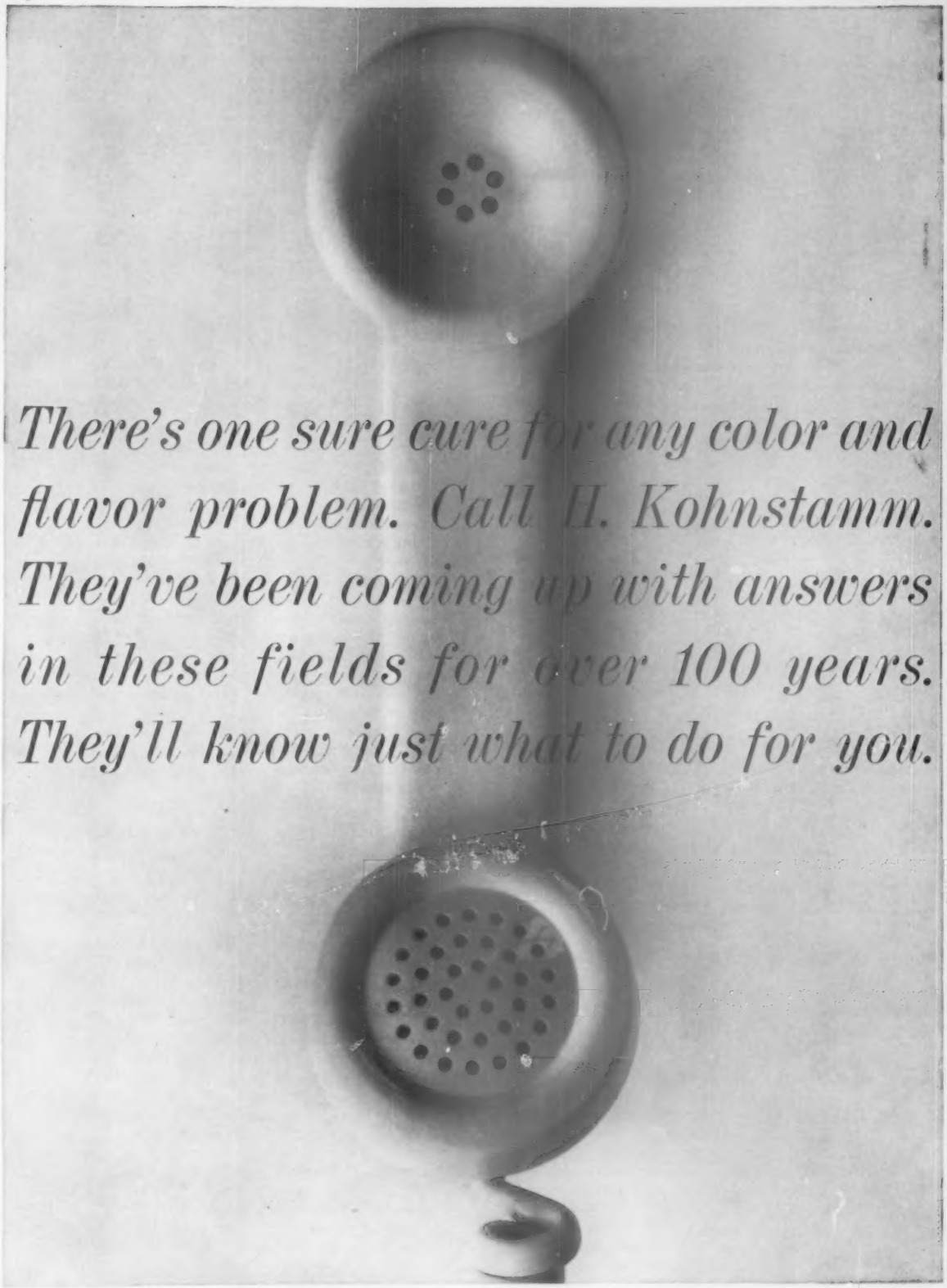
The exudation of liquid from prepeeled potatoes on storage is undesirable because it reduces the shelf life of the product and produces an unsightly and unsanitary appearance. It can be minimized by adding 10 p.p.m. of oxytetracycline or chlortetracycline to the sulphite dipping solution for French-Fry style strips packed in polyethylene bags. Five p.p.m. of either antibiotic was effective for French-Fry strips in Cryovac bags. Both antibiotics were equally effective at 38° F. and at 50° F. but the shelf life was much shorter at the higher temperature. Oxytetracycline was effective in reducing exudation and extending shelf life even with potato strips inoculated with spoilage organisms from a previous pack. Oxytetracycline also exerted a protective effect as shown by lower alcohol content and firmer potatoes when the strips had undergone some chemical injury due to treatment with an excess of sulphite and phytic acid or calcium phytate. (See page 485).

Quality evaluation *Dill pickles*

Effect of sugar, storage time and temperature on dill pickle quality. Rose Marie Pangborn, Reese H. Vaughn, George K. York II, and Marlene Estelle.

Quality changes in dill pickles as influenced by sugar, storage time, and temperature were considered. Genuine dill pickles varying in sugar content (0, 2, and 4% sucrose) were stored at 34, 70, 86, and 98° F., then evaluated after "0", 4, 8, 16, and 32 weeks. The sample containing 2% sugar was the most desirable in flavor, texture, color, and over-all acceptability. The data suggest that sugar served to protect the pickles against adverse color changes which occurred at the lower temperatures of storage. The pickles softened considerably with increasing time and temperature of storage except when maintained at the two lowest temperatures. Refrigeration temperature (34° F.), however, caused an undesirable color development which had an inverse relationship to softening, suggesting that apparent color changes were alterations in cellular structure rather than change in hue. Temperatures of 70° and 86° F. resulted in smaller quality changes than did temperatures of 34° and 98° F. The lowest quality was observed after 16 weeks of storage with little subsequent deterioration. There were no significant effects of added sugar, time, or temperature of storage upon the total acidity, pH, salt content, or vacuum of the capped jars. Good positive correlation between shear-press values and texture scores was obtained. (See page 489).

September Cover. The cover for September presents a mosaic of candid photographs of various IFT meetings. A, upper left, records photographically the reactions of an audience at a Regional Section meeting, specifically, the discussion period. In B the speaker of the evening is warming up to his topic. C gives a glimpse of the Awards Banquet, Philadelphia Annual Meeting. In D a Regional Section audience evaluates the remarks of the speaker. E portrays a joint meeting of two Regional Sections gathered for a plant tour (Hormel's) and an outing.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Correlation of subjective and objective tests — *Beef quality*

Interrelationships of subjective, chemical, and sensory evaluations of beef quality. D. H. Kropf and R. L. Graf.

The interrelationships of various subjective, chemical, and sensory evaluations of beef quality were studied to determine which factors are most closely related to final eating qualities. Three hundred and thirty-four beef carcasses representing a wide range of grades, classes, and carcass weights were used. As the beef animal matured, a pronounced tendency existed for carcass lean muscle to become more coarse textured and darker colored. A greater round index (ratio of circumference to length of round) was closely related to a higher degree of finish (fat covering or feathering) and through these factors also related to tenderness. Fat covering was closely related to marbling, lean firmness, color of lean, tenderness, flavor and ether extract of the loin eye. Sensory preference had a correlation coefficient of .53 (significant at 5% level) to tenderness and correlation coefficients of .43 and .17 (non-significant at 5% level) to sensory flavor and juiciness, respectively. Preference was also significantly related to carcass length and weight. Tenderness of lean increased as external and internal finish increased and as lean became firmer. Juiciness had a significant correlation coefficient of .54 to sensory tenderness. Mechanical shear values were highly related to sensory tenderness and appeared to be more sensitive as a measure of tenderness. Subjective marbling score *vs.* ether extract of the loin eye showed a significant correlation coefficient of .74. Water loss and hydroxyproline content were not significantly related to any subjective and sensory evaluations in this study. (See page 492).

Standard grading method — *Pectin*

Pectin standardization. Final report of the IFT committee on pectin standardization. (Members are listed in the article.)

Historical background, brief summary of the Committee's work, a proposed standard procedure for grade evaluation of pectins, designated Method 5–54 of the IFT Committee on Pectin Standardization are the main phases of this article. Pertinent literature is cited. (See page 496).

Radiation preservation — *Raw beef*

Some factors influencing irradiation induced chemical changes in raw beef. O. F. Batzer, R. A. Sliwinski, Lucy Chang, Katherine Pih, J. B. Fox, Jr., and D. M. Doty.

When hot melt, diacetin fat, and agar with added plasticizer were used as coating materials for fresh meats, microbial proliferation was retarded. The hot melt and the modified fat prevented desiccation but meats protected with these coatings had undesirable color. A layer of plasticized agar did not prevent excessive drying unless the meats were also overwrapped with film. Incorporation of chlortetracycline into Pliofilm delayed microbial growth and maintained desired surface color of meat for a longer period of time than did the film alone. An inverse relation was shown between keeping time and temperature of storage. At 5° C., packaged steak wrapped in film containing 0.4 part CTC/100 parts rubber hydrochloride did not develop off odor until 2 days after the control meat had shown similar signs of spoilage. Numbers of organisms proliferating on meat wrapped in CTC treated Pliofilm were invariably less than those on meats packaged in the control film. Temperature of storage of plates had only minor influence on microbial recoveries. Reflectance readings at 580 mμ and 635 mμ indicated a 2-day lag in discoloration for meat packaged in film impregnated with CTC. Studies with film containing smaller amounts of CTC in the rubber hydrochloride base also indicated less rapid microbial proliferation and less discoloration than did the control packages. Maximum-minimum reflectance readings at 580 and 635 mμ for oxymyoglobin and metmyoglobin respectively were not found until bacterial populations had caused off odor. (See page 501).

Curing of meat — *Minimum level of sodium chloride*

The influence of sodium chloride on toxin production and organoleptic breakdown in perishable cured meat inoculated with Clostridium botulinum. Richard A. Greenberg, John H. Silliker, and Louis D. Fatta.

The minimum level of sodium chloride capable of preventing toxin production in perishable meat was studied. Toxin formation by *Cl. botulinum* was observed in inoculated perishable cured meat with no accompanying organoleptic degradation of the product. This occurred in product containing 6.25, 7.09 and 7.12% brine. A batch of 1½ lb. ham pieces, cured to comply with existent safety standards (5.5% brine minimum) showed wide variance when analyzed at termination of cure. Forty-nine per cent of the lot contained brine in the 6.10–8.35% range. Marketing of a perishable product, the mishandling of which could result in *Cl. botulinum* toxin formation without warning to the consumer, could constitute a public health hazard. The data suggest that in a perishable cured product the level of salt must be within the range wherein botulism toxin formation is attended by obvious organoleptic breakdown (below 6.25% brine). Alternatively the salt level may be such that toxin formation is inhibited (about 9%). (See page 509).

Packaging — *CTC impregnated films for fresh beef*

Use of coating material or film impregnated with chlortetracycline to enhance color and storage life of fresh beef. John C. Ayres.

Use of coating materials or films infused wih antibiotics may have important significance for the meat industry since most of the organisms are confined to the surface and most spoilage problems are surface phenomena. Also, by conventional methods of cookery, meat usually receives adequate heat treatment to inactivate antibiotic residues at the surface. This article reports research undertaken to determine if the storage life of sliced fresh meats could be prolonged by incorporating an antibiotic into a coating material or a packaging film. When Experimental Resin X-2203.6, hydrogenated diacetins, and agar with added plasticizer were used as coating materials for fresh meats, microbial proliferation was retarded. The hot-melt resin and the hydrogenated diacetins prevented desiccation but meats protected with these coatings had undesirable color. A layer of plasticized agar did not prevent excessive drying unless the meats were also overwrapped with film. Incorporation of chlortetracycline into Pliofilm delayed microbial growth and maintained desired surface color of meat for a longer period of time than did the film alone. Maximum-minimum reflectance readings at 580 and 635 mμ for oxymyoglobin and metmyoglobin, respectively, were found at

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about the same time that bacterial populations caused off odor. (See page 512).

Consumer preference *Beef of different breeds*

Consumer preferences for beef of different breeds related to carcass and to quality grades. Marilyn Dunsing.

Preference evaluations of a consumer household panel for steers differing in breed and grade were obtained. These evaluations were grouped for analysis on the basis of both carcass grade and quality grade. Analysis of the data indicated that preferences were more closely related to quality than to carcass grade. Visual preferences did not appear to be related to breed except for color, a preference being indicated for the darker-color steaks of the Holstein. Eating preferences were significantly related to breed and grade. The quality grade grouping, however, gave a better indication of the effects both of breed and of grade than did the carcass grade grouping. For the two groupings, eating preferences of panel members tended to be reversed for the wholesale cuts; they were in favor of Holsteins for steaks from the short loin cut and of Herefords for those from the sirloin cut. Average differences between breed ratings for the over-all preference categories indicated that for Herefords the degree of preference was highest for tenderness; for Holsteins it was highest for taste. (See page 516).

Antibiotic treatment *Chlortetracycline residues in meat*

Effect of storage and of cooking on chlortetracycline residues in meat. Ofelia I. Escanilla, Agnes Frances Carlin and John C. Ayres.

To determine the residual CTC in meat after storage and after cooking, ground beef was treated with CTC to contain 1.7, 5.0 or 15.0 μg./g. of the antibiotic. After about 28 hours at 42 ± 2° F., the residual CTC in the raw meat was about 66% of the antibiotic originally added to the meat. CTC residues in the cooked ground meat decreased as the final internal temperature was increased. Residues of CTC at any given temperature were a direct function of the initial concentration in the raw ground meat. The results also indicated that residual CTC in cooked meat patties was a logarithmic function of the internal temperature at the end of cooking. In frankfurters, the greatest loss of CTC occurred during the commercial processing in the packing plant. Only about 15% of the CTC added in the meat emulsion (15, 30 or 45 μg./g.) was detected in the raw frankfurters. After cooking the frankfurters in boiling water to 181° F., the CTC concentration was reduced approximately 50%. Thus processing and cooking resulted in a total inactivation of 85–95% of the CTC in frankfurters. Regardless of treatment level of CTC or the temperature attained during cooking, the antibiotic in the meat was not reduced to undetectable amounts. (See page 520).

Prolonged storage (43 years) *Strawberry preserves*

The effect of forty-three years of storage on strawberry preserves. G. E. Livingston and Chee Teck Tan.

A sample of home-made strawberry preserves packed in 1915 by a lady in Sutton, Mass. and stored in a dry cellar for 43 years was examined. Data indicated that short-term high-temperature storage (100° F.) to simulate chemical changes occurring in preserves over extended storage at room temperatures is justified. Flavor changes under such accelerated conditions may not parallel those of long-term storage. (See page 525).

Packaging *Partially baked rolls*

Light destruction of riboflavin in partially baked rolls. Lois Carter Stephens and Marian Faulkner Chastain.

Yellow and orange colored cellophanes were tested for effectiveness in reducing photolysis of riboflavin in partially-baked rolls. Both wraps resulted in increased riboflavin retention as compared to clear cellophane-wrapped controls. The orange cellophane afforded greater protection than did the yellow. However, losses of riboflavin were small even in the control samples. It is not likely that the amount of riboflavin lost in partially-baked rolls is of nutritional importance. (See page 527).

Antibiotics *Application to beef*

A comparison of the methods for applying Acronize[a] chlortetracycline to beef. M. C. Firman, H. J. Bachmann, F. J. Heyrich, and P. F. Hopper.

Effectiveness of chlortetracycline for extending the shelf life of beef was demonstrated and various methods for applying the antibiotic were compared for such use. The ability of the antibiotic to prolong the salability of beef was dependent upon its level in the meat and that level was, in turn, related to the application method. At the amounts used, chlortetracycline was most satisfactory when administered by both an intravenous injection to the live animal immediately before slaughter, and as a spray immediately after slaughter. In order of decreasing effectiveness were the injection, the spray, and finally the treated cellophane methods of application. (See page 529).

[a] The trademark of American Cyanamid Company for the food grade of chlortetracycline is Acronize.

Freezing technology *Broilers*

Prevention of darkening in frozen broilers. Cordelia Ellis and J. G. Woodroof.

Darkening of meat near thigh and leg bones of young chickens during freezing, thawing, and cooking detracts from the appearance of the product. The kind of feed, methods of bleeding, rate of chilling, and time in frozen storage had little or no influence on meat darkening. However, meat discoloration was prevented by heating the chicken parts to an internal temperature of 180° F., before freezing. This was accomplished, in order of preference, by heating with microwaves, steam at 10 pounds pressure, steam at atmospheric pressure, radiant heat oven at 350° F., or deep fat at 350° F. Heating with microwaves was highly effective, required 2 to 3 minutes, and resulted in 18.6% weight loss; heating with steam pressure was also effective, required 5 minutes and resulted in 16.5% weight loss. Other methods were slightly less desirable. Meat and bone darkening was increased by allowing the chicken to completely thaw before beginning cooking. Chicken preheated with microwaves (4 or 5 pieces at one time) for more than 3 minutes, or with radiant heat for more than 25 minutes, then wrapped individually in aluminum foil, and held 2 years at 0° F., was stale and rancid. The larger pieces retained flavor and freshness much better than the smaller pieces. (See page 533).

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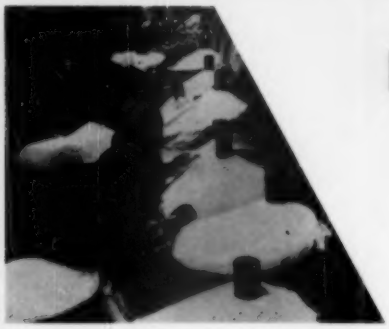

Food Technology in Haiti

Harold S. Olcott
Department of Food Science and Technology
University of California, Berkeley, California
and
Gabriel Nicolas
Department of Agriculture, Damien, Haiti.

THE REPUBLIC of Haiti occupies 10,000 square miles of the western part of the island of Hispaniola. The terrain is quite mountainous. The plains area suitable for intensive agriculture accounts for about 10% of the total area of Haiti. The approximately 4,000,000 inhabitants are 90% rural, 90% illiterate, and 90% very poor.

During June of 1958, a nutrition survey team, sponsored by the Williams-Waterman Fund of New York, and headed by Dr. W. H. Sebrell, Jr., made a study of the nutritional status of the civilian population of Haiti, with the ultimate objective of being able to furnish recommendations to the Haitian Government for a nutrition-betterment program. The methods used were those adopted from the *Manual for Nutrition Surveys*, developed by the Interdepartmental Committee on Nutrition for National Defense, U. S. Government. The manual calls for a food technologist to be on the team in order to gauge the present status of food technology in the country to be studied, and to help make recommendations with respect to changes which would benefit the populace. The following is a digest of some of the information which will appear in more detail in the complete report.

Farming by hoe and machete

Farming is primitive. There are few plows or tractors in Haiti, and these are confined to large estates on which sugar cane or sisal are grown. Most farmers have only a hoe and a machete. At the time of the survey there was practically no use of fertilizer, insecticides, weed-killers, etc. A fertilizer plant is now planned. The people live mainly on cereal crops (corn, millet, rice), root crops (sweet potato, casava, yautia), plantain and beans. Many fruits grow wild. These, together with a variety of green leaves used in cooking, are a lifesaving factor in the nutritional picture. The amounts of meat, fish, eggs, and milk consumed are very limited.

Food processing in the modern sense is non-existent. There are no canning, freezing, dehydration, or pickling plants. At one time it was thought that a pineapple-canning plant might profitably be operated, but the project was dropped before the factory was fully constructed.

Sugar

Sugar cane is a principal crop and sugar can be exported to provide much needed funds. The Haitian-American Sugar Company (HASCO), Port-au-Prince, has a mill with a capacity for producing up to 75,000 tons of sugar annually. Production varies, depending upon the availability of cane. About 40,000 tons of this sugar is consumed in Haiti. Surpluses are exported. Thus in 1955–56, 36,000 tons of crude sugar were exported; 32% to Japan, 25% to the United Kingdom, and the rest to the United States, Belgium, and Korea. Molasses is disposed of by export. Production of this company for Haitian use is distributed as refined sugar, about 22%, and the rest as "sucre populaire," which is about 97% sucrose. The two sell at present for about 8 and 6 cents per pound, respectively. Small sugar processors operate at Cap-Haitien and Cayes. The production of these plants is estimated at 1,500–3,000 tons annually, but the capacity of the latter is 20,000–30,000 tons. Lack of available cane and the low sugar content of the local crop account in part for the small production of the Cayes mill. At present this production seems to be growing. There are plans for building two new sugar mills in the Artibonite Valley, where the introduction of cane may follow the development of new irrigation projects, as spurred by the completion of the dam at the head of the Artibonite Valley. Based on estimates that the mills absorb only about one-half of the cane grown in Haiti, that most of the rest is crushed to juice, and that half of this is used to make edible sugar products ("sirop" and "rapadou"), it may be calculated that the annual per capita consumption of sugar from cane is 30 to 40 pounds. This is considerably less than the 100 or more pounds of sugar per capita consumption of some of the more highly developed countries.

Cottonseed oil

Two companies divide about equally the manufacture of cottonseed oil. These are Huilerie Nationale, S. A., and S. A. Usine a Manteque de Port-au-Prince, both at Port-au-Prince. These mills are equipped with conventional gins, cookers, and presses and were operated at or near capacity when cotton production was high. This has, however, been gradually falling during the past 20 years, due in part to the encroachment of the boll weevil and in part to lack of incentive of the grower to take care of or to reap his crop. The local cotton plant is a perennial *(Gossypium barbadense)*. The production of cottonseed has thus fallen from about 14,000 tons to about 3,500 tons annually. The Haitian requirements for edible oils are met by the importation of lard, crude soybean oil and smaller

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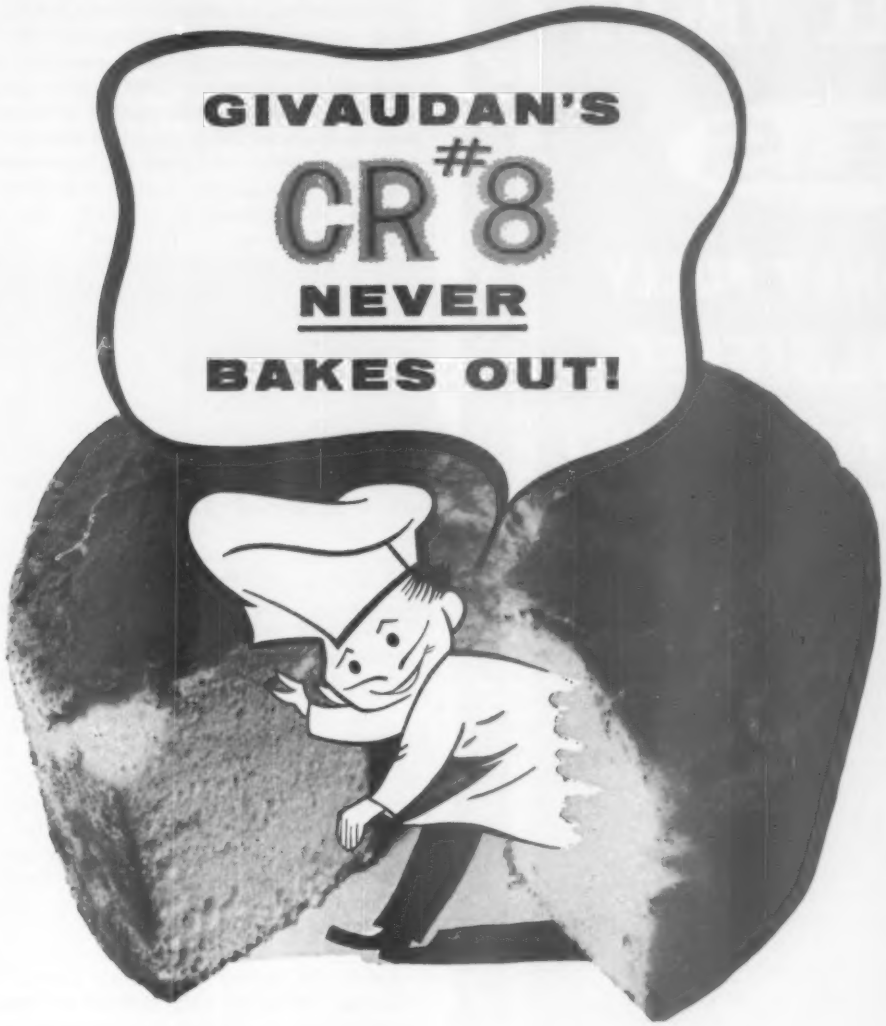

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amounts of other oils. In 1955–56, 3,600 tons of lard and 1,100 tons of soybean oil were received; together with an estimated production of 500–1,000 tons of local cottonseed oil, the total available processed fats and oils accounts for 5,000–6,000 tons. Thus, the average per capita consumption of processed oils and fats in Haiti is 2.5–3 pounds annually. The Haitian processors refine both their own cottonseed oil and the imported soybean oil. Imported hardened fat is used for the manufacture of a blended vegetable fat compound. There are no facilities for hydrogenation or solvent extraction of cottonseed cake. Perhaps one-third of the cake is used in Haiti as cattle feed or fertilizer, the rest is exported.

Coffee—the mountain coffee grows wild

Coffee is the most important single source of revenue to the government, comprising 65–80% of the value of total exports. About one-fifth of the crop is used locally and the rest, amounting in 1955–56 to about 34,000 tons (valued at $33,400,000) is exported. Drying and decortication are carried out by all techniques from the most primitive to the use of the best modern equipment. There are no large plants but a number of coffee driers and decorticators are scattered throughout the country. Much of the mountain coffee grows wild and untended, except for the few days when the owner harvests the berries.

A small outlet for our wheat surplus

A wheat flour mill, Caribbean Mills Company, Port-au-Prince, was erected in 1957–58 and began operations in November, 1958, on imported wheat. Bread and other wheat products are popular foods, but wheat is not a satisfactory crop in Haiti. The requirement for wheat flour has hitherto been met by importation, mostly from Canada and the United States. In 1956–57 this amounted to 37,000 tons (approximately 20 pounds per capita annual consumption). An agreement with the Haitian Government required that as soon as the mill began operation, wheat but no wheat flour could be imported. The mill has a capacity to handle 270 tons of wheat daily and is expected to produce 350,000 pounds of high protein flour. If it should operate three hundred days a year at this capacity, it will produce 52,000 tons of flour or approximately one-third greater amount than Haiti can absorb. It is planned to export this surplus to surrounding Caribbean Islands. Unless a market can be found in Haiti, the daily yield of 35 tons each of shorts and bran will be exported. No consideration has been given to a possible enrichment program.

One-room rice mills

A small clean rice milling plant is run by the ODVA (Organisme de Development de la Vallee de l'Artibonite) in the Artibonite Valley as a service to the rice growers of the area. In general, however, rice is milled at home in large wooden mortars or is taken to one-room mills in the villages. Most of the equipment in these small mills is of Hamburg origin. Some-

times rice is parboiled at home, for example, by heating a large drum containing a small amount of water and filled with rough rice (about 50 pounds). After the rice is thoroughly steamed, it is spread on cement slabs to dry in the sun (Figure 1). The hardened kernels are valued because the yield during milling is greater. Increases in yield of as much as 20% are realized. There is no recognition of the nutritional benefits of parboiling.

Figure 1. Drying of rice on a cement slab at Petit Reviere de l'Artibonite.

Grinding corn

Corn grinding equipment is similarly small and widely scattered. The peasants themselves sift the ground corn so that both flour and coarse meal of many different grades are offered in the local markets, a glimpse of which may be seen in the cut opposite the title of this article.

Potstill products

A large modern distillery and many primitive stills produce the alcoholic requirements. Yeast fermentation of concentrated cane juice or diluted cane molasses provides the raw material for these stills. Clairin (25–30% alcohol) and tafia (10–15% alcohol) are crude potstill distillates. The amounts of these and of rum consumed are not known. If the equivalent of 20,000 tons of sugar are fermented, one may estimate that 10,000 tons of alcohol are produced or roughly 5 pounds of alcohol (1–2 gallons of rum) annual per capita consumption. This figure may be greatly in error.

Salt by solar evaporation in dirt basins

Salt is manufactured in Haiti in the Gonaives and Port-au-Prince areas by solar evaporation of sea water in dirt basins (Figure 2). When sufficient crystals are formed on the sides and bottoms and on branches which are used to increase the surface for crystallization, the salt is harvested by hand. The branches are stripped into wicker baskets, the crude salt is washed with the mother liquor and dried in piles in the sun.

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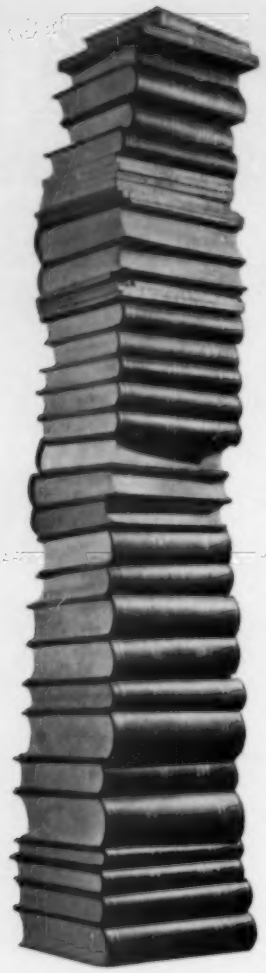

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Figure 2. Harvesting salt at Gonaives.

This grayish large crystal salt comprises most of the salt marketed in Haiti. According to M. Routh, FAO Fisheries Specialist, the impurities render it unsuitable for salting fish. Any increase in the latter activity would require either the introduction of techniques for purifying salt or the importation of salts of higher purity. The nutritional survey showed that in the females studied the incidence of palpable enlargement of thyroids was surprisingly large—17–39% for the various groups studied. This suggested that the salt contained little or no iodide and preliminary laboratory observations confirm this. Iodization of the salt would be of obvious nutritional benefit, but a practical way to accomplish this under the present methods of manufacture and distribution is difficult to visualize.

Fish

The Haitians import about 14,000,000 pounds of dried and salted fish annually, mostly from Canada, although tuna and related species are supposedly abundant in the surrounding waters. A vigorous program supported by FAO laid the ground-work for a proposed cooperative agreement between a Japanese fishing company and the Republic of Haiti, by which, in return for permission to use Haiti as a base for operations and to build an 800-ton refrigerated warehouse in Port-au-Prince, the fishing company would help the Haitians train fishermen, develop a fishery and a distribution system. However, little progress has been made on this project. An increase in fish consumption would help to overcome the obvious protein deficiencies, particularly in the rural areas.

Essential oils—from amyris to vetiver

One large and ten or twelve small essential oil plants are scattered throughout the country. The oils manufactured are amyris, lemon grass, lime, vetiver, and others. Total exports in 1955–56 amounted to 260,000 pounds, but accurate data on present rates of manufacture are very difficult to obtain.

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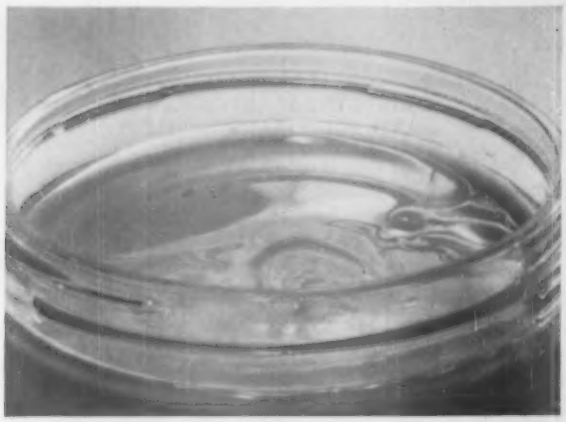
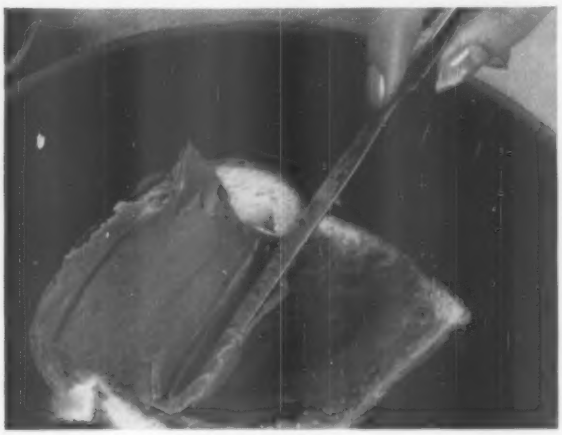


2. "Oil-out" in peanut butter can be eliminated, on the same principle, when the butter is stabilized with *Myverol*® *Distilled Monoglycerides*. To imprison the oil, you need only 2½% mono. The matrix won't dissolve even on the warmest summer day.



3. The peanut butter doesn't stiffen in the refrigerator, either. Since virtually all the stabilizer is already crystalline, there is none left in solution to crystallize later at low temperature. Spreadability stays just right, just the way you want it.

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The following comments may be made on some of the crops of Haiti. Corn is grown in all parts, and on almost every square foot of plantable land, including the sides of drainage ditches, steep and stony hillsides, etc. Yields per acre are therefore extremely poor. However, even on good land agricultural practices are wasteful and fail to take advantage of information already available. Thus fields may be and are extensively damaged by insect infestation which the application of a few cents' worth of insecticide could have prevented. The peasant often has neither the few cents nor the information necessary to do this. Yields could also be tremendously increased by irrigation where this is possible, by the use of new seed, and by the adoption of already developed practices of more advanced agricultural regions. Millet and sorghum are more resistant than corn and can be grown in areas where corn will not produce a comparable yield (Figure 3). Rice is a favorite cereal in the Haitian diet but is more expensive than corn or millet. In the irrigated areas, seed imported from the southern United States is found to give the best yields. A mountain rice is grown in those areas of higher elevation which have adequate rainfall. In the Artibonite Valley now being artificially irrigated as previously mentioned, about 40 square miles are being devoted to rice culture (Figure 4). Other high-yielding crops which furnish a large proportion of the calories to the Haitian peasant are plantain, sweet potato, yautia (the Haitian "malanga"), and yams (*Dioscorea sp.*, spelled "igname" in Haiti, large, irregularly-shaped roots, not resembling our sweet potato). Bananas, which a few years ago were a profitable export crop, have declined drastically due to Panama and other diseases; 7,300,000 "stems" were exported in 1946-1947, 164,000 in 1955–1956.

Figure 3. Experimental plot of millet near Gonaives.

Figure 4. Irrigated rice fields in the Artibonite Valley.

Summarizing, one finds in Haiti a large undernourished and illiterate population dependent upon a subsistence agriculture and an underdeveloped industry. Improvements are hampered by lack of capital, schools, teachers, roads, and political stability. The Department of Agriculture staff at Damien is doing an excellent job as far as their resources permit in overcoming some of the agricultural deficiencies, but progress in solving some of the other problems will unfortunately be slow.

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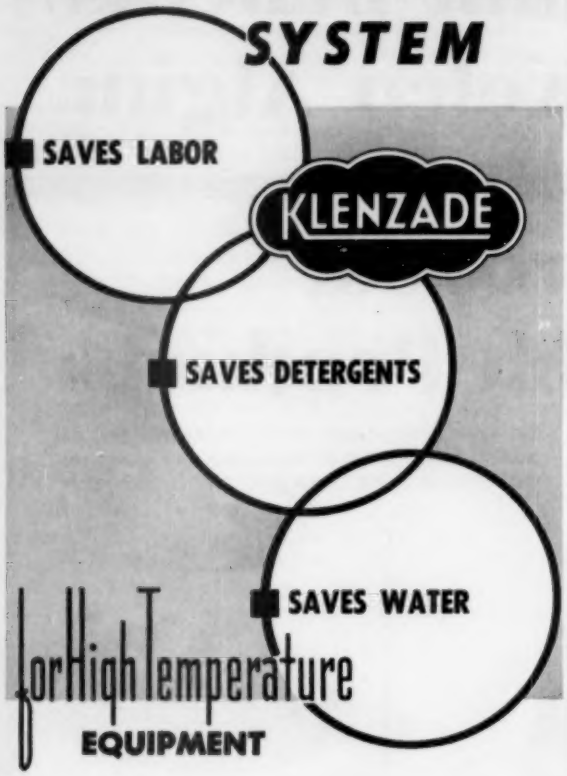

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Twentieth Annual IFT Meeting Plans Under Way

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"IFT members and guests can look forward to a stimulating and timely array of speeches, technical sessions, awards presentations, and a fine selection of industrial exhibits"; according to Mr. John Kilbuck, (Wm. J. Stange Co.), General Chairman of the 20th Annual Meeting. Plans for the technical sessions are well under way according to Dr. George F. Stewart (Department of Food Science and Technology, University of California), Program Chairman, and Dr. Hans Lineweaver (Western Utilization Research and Development Division, USDA), Vice Chairman.

J. Kilbuck

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Dr. George Felton, Hawaiian Pineapple Company
Dr. Dean Foster, M. & M. Foods, Inc.
Dr. Joseph H. Gast, Baylor University
Dr. Amihud Kramer, University of Maryland
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Deadline for Program Participants

In order to meet publication deadlines, prospective contributors should submit titles and abstracts to the Program Chairman according to the following schedule:

1. *Titles* must be in the Chairman's hands *not later than December 1, 1959.*
2. *Abstracts* must be in the Chairman's hands *not later than January 1, 1960.*

Tentative List of Special Sessions

While final decisions have not been reached by the Program Committee, special sessions will probably be scheduled for the following subjects:

A. San Francisco Sessions

1. Food Engineering
2. Progress in Producing and Marketing Instant Foods
3. Quality Control in Food Processing and Marketing
4. Basic Research on the Chemistry of Foods and Food Components
5. Food Microbiology
6. Fruit and Vegetable Technology (with a special session on citrus products)
7. Cereal and Baked Products
8. Animal Products Technology
9. Food Additives and Food Toxicology
10. Packaging Problems

B. Hawaiian Sessions

1. Technical Tours of Fruit Production and Processing Centers on Island of Oahu and Hawaii
2. Potentials for Processing and Marketing Exotic Fruits of the Pacific Rim
3. Potentials for Processing and Marketing Animal Products for use in the Pacific Rim Area.

Of Professional Interest

Nominations Now Open for Food Technology Industrial Achievement Award

The Institute of Food Technologists, Donor, announces the opening of nominations for the second FOOD TECHNOLOGY ACHIEVEMENT AWARD. The award consists of the following: To the Company or Institute, a bronze plaque. To the individual(s) judged to have made major contributions to the achievement, either through basic research or development, public recognition at the time of presentation of the Award, and an engrossed plaque.

The purpose of this award is to recognize and honor an outstanding food process and/or product, which represents a significant advance in the application of Food Technology to food production, and which has been successfully applied in actual commercial operation at least six months but not over four years prior to the date of calling for nominations. Insofar as possible, this Award shall be personalized by public recognition of the individual(s) responsible for the achievement.

CALL FOR NOMINATIONS

Any member of the Institute of Food Technologists may make nominations for the Award. Each nomination must be in letter form and include the following:

Name of Company or Institution.

Name of Product and/or Process.

Description of Product or Process.

Statement of reason for considering this a meritorious achievement.

Statement listing individuals chiefly responsible for the achievement and their individual contributions.

Statement indicating the time and extent of commercial utilization.

Nominations must not exceed three, single-spaced, typewritten pages. December 1st is the deadline for receiving nominations. Send nominations to the Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois.

Time-Temperature Tolerance of Frozen Foods. XIX.

Ready-to-Cook Cut-up Chicken*

A. A. Klose, M. F. Pool,
A. A. Campbell, and H. L. Hanson
Western Regional Research Laboratory,[b] Albany, California

(Manuscript received March 14, 1959)

OVER ONE BILLION POUNDS of poultry meat are marketed annually as a frozen, ready-to-cook product, and a substantial proportion is sold in packaged, cut-up form. It is important, then, to know how these products stand up under a wide range of commercial conditions of time and temperature, and what the requirements are for processing and packaging to provide desired stability. Only from such information will it be possible to develop criteria of excellence and quality loss and to establish safe tolerances for all phases of processing and distribution. Pertinent data have been published from this laboratory on frozen whole roaster turkeys *(5)*, turkey dinners and turkey pies *(2)*, and frozen fried chicken *(3)*, as part of the comprehensive study of the time-temperature tolerance of frozen foods outlined by Van Arsdel *(14)* in the first article of this series. The present report extends the data to include ready-to-cook chicken.

During the past 15 years, in which ready-to-cook (eviscerated) poultry has replaced dressed (non-eviscerated) poultry as the predominant marketing form, there has been an increasing interest in the storage stability of frozen, ready-to-cook poultry. Koonz et al. *(6)* reported appreciable deterioration in flavor and appearance of eviscerated, disjointed pullets wrapped in moisture-proof cellophane after 9 months at 0° F. and after progressively shorter periods as the storage temperature was increased to +10°, +20°, and +28° F. Wills *et al. (15, 16)*, in studies on fryer and roaster chickens with variations in packaging (waxed carton versus tin can), found important quality losses at +20° F. in less than 3 months, but at 0° F. only after 9 months. Beneficial effects of good packaging were much more evident at +20° than at 0° F. Analysis of the atmosphere in air-packed cans after 9 months' storage at +20° F. indicated that practically all of the oxygen had been consumed and carbon dioxide content had risen to about 16%.

Cook and White *(1)*, in early studies on rancidification and dehydration of poultry (presumably New York dressed) at +10° F. under various degrees of packaging protection, established that poultry fat could become definitely rancid under storage conditions that prevent surface drying. To our knowledge there has been no rigorous extension of this work to ready-to-cook poultry with complete and independent control of oxygen availability and moisture retention over wide limits. A summary of effects of frozen storage on eviscerated poultry by Stewart and Lowe *(12)* indicated the importance of tight, moisture-vapor-proof packaging in controlling visible dehydration for 6 to 9 months at 0° F.

Parnell *et al. (8)* compared quality losses of fryers held at 0°, 7°, 15°, and a fluctuating temperature ranging between 2° and 15° F. The fluctuating condition, with a mean temperature estimated to be between 2° and 7° F., resulted in about the same amount of moisture loss after 6 months' storage as the steady 7° F. condition. Studies on large, ready-to-cook roaster turkeys reported earlier *(5)* from this laboratory involved 4 constant-storage temperatures (−30°, −10°, 0°, +10° F.) and a temperature fluctuating between −10° and +10° F. in a 24-hour sine wave cycle. Moisture loss from wax paper wraps increased with increase in temperature and for the fluctuating −10° to +10° F. condition was equal to the loss to be expected from a steady +3° F. In relatively moisture-impermeable plastic bags, frost formation increased with temperature and was higher for the −10° to +10° F. fluctuating temperature than for the steady +10° F. With relatively moisture-impermeable packaging, fluctuating temperatures within the range of −10° to +10° F. were inferior to the mean steady temperature (0° F.) only with respect to frost formation, and this had no effect on eating quality.

The present paper extends the existing state of knowledge as described above through detailed evaluation of quality losses over a wide range of temperatures, temperature fluctuations, and storage periods and for various degrees of adequacy of packaging. Studies include storage tests in controlled atmospheres where moisture loss and oxygen availability were varied independently and their separate effects determined. Results emphasize the importance of good packaging in addition to low (0° F.) temperature storage, and provide evidence to support a recommendation for inert gas packing where additional storage life is desired.

GENERAL PROCEDURES

Frozen commercially packaged, cut-up chickens were obtained from a uniform lot processed in a typical processing plant and were randomly distributed among the experimental temperature conditions. Refrigerated storage rooms *(7)* used in these studies maintain accurately any steady temperature or

* Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 20, 1959.

[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

any prescribed recurring cycle of fluctuating temperatures, with a uniform air flow (40 f./min.) directed from perforated double walls equally over all of the stored samples. Each package was weighed and placed on its side on wall shelves in a refrigerated storage room, with adequate air space between adjointing packages, and with the greatest surface at right angles to the perforated double wall to permit uniform and maximum air flow over the package surfaces. After storage periods estimated to have produced significant differences in quality between the various experimental conditions, packages were removed, weighed, examined for deterioration in frozen appearance or odor, thawed overnight at +37° F., and evaluated for off odor in the thawed raw meat and off flavor in the cooked product. Peroxide development in the raw skin fat and visceral fat of stewing hens was determined by modification of the iodometric method of Wheeler *(9)*.

Cooking of chicken fryers was accomplished by dredging the pieces of cut-up chicken in flour (1 part potato flour, 2 parts all-purpose flour, and salt at 10% of total flour) and deep-fat frying for 12 to 15 minutes (depending on size) in peanut oil at a starting temperature of 268° F. and a cooking temperature of 250° F. Livers and gizzards were cooked in water for one hour in a double boiler. Livers were submitted to a taste panel of 4 to 5 judges. Gizzards were not tasted but were sliced and the interior color noted. Stewing hens were steamed in an autoclave at 212° F. for 2 hours. Four birds per experimental group were used in each organoleptic comparison.

For organoleptic evaluation, samples were ranked, 1 being assigned to the least off flavor or odor, 2 to the next, etc. In most cases, paired comparisons were made of corresponding parts of 2 birds, an experimental and a control, and in no case were more than 4 samples compared at one time. Eight judges ranked samples with respect to off-odor of the raw meat, off odor in the broth, and off flavor in the skin of stewing hens. Throughout any experiment, 4 judges ranked light meat samples for off flavor and 4 other judges ranked dark meat. There were 4 replications of each comparison, making a total of 32 judgments from which to estimate the nature and statistical significance of the panel finding. The results obtained at successive storage periods are expressed in terms of the time, for each experimental temperature, at which the panel was first able to rank the experimental birds significantly worse than the controls held at −30° F. or −10° F. The industry has indicated interest in this end point, which may be considered to terminate the period of "high quality storage life," although it is recognized that when tasted alone under normal consumption practices, these samples would be acceptable for considerably longer periods.

Statistical analysis of the taste data was made by the use of tables of the binomial probability distribution *(13)*, with a requirement for significance arbitrarily set at the 1% level of probability in most cases. For example 24 correct judgments (ranking the control 1) were required out of a total of 32 judgments before significant deterioration was considered to be present. In Experiment A, where most of the pertinent comparisons never resulted in a difference significant at the 1% level within the periods studied, data are given for a 5% level of significance.

EXPERIMENTAL WORK AND DISCUSSION

Experiment A. *Fryers in excellent commercial package.* An experiment on the storage stability of cut-up chickens was designed to cover temperatures ranging from −10° to +20° F. and including 2 fluctuating conditions, −10° to +10° F. and 0° to +20° F. The nature of the imposed fluctuations is illustrated in Figure 1 for the 0° to +20° F. cycle, which had a sine wave form and a period of 24 hours. While the air temperature in the storage room ranged over 20°, product temperature varied over a 16° to 17° span and lagged behind the room temperature by about 3 hours. Air temperature in the package fell in an intermediate position. The −10° to +10° F. fluctuation was also of a 24-hour, sine wave form.

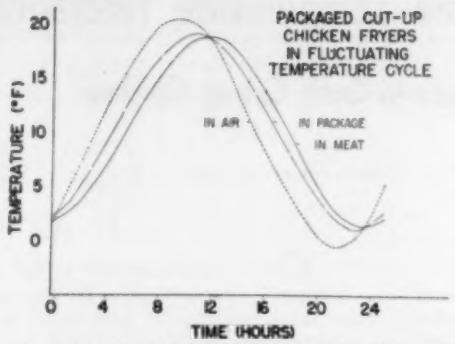

Figure 1. Pattern of continuously fluctuating temperatures imposed on one group of well packaged cut-up fryers in Experiment A.

Samples in this storage test were commercially raised, meat-type, chicken fryers processed and packaged at a commercial plant under Federal inspection. Each semiscalded, warm-eviscerated, ice-chilled carcass was cut into 10 pieces—wings, drumsticks, thighs, 2 pieces of back and 2 pieces of breast—and then packaged and blast frozen at −30° F. The package was a superior commercial type, consisting of a 1-mil-thickness cellophane inner liner, a telescoping two-piece rectangular carton, and a sealed 1-mil cellophane overwrap. In this and subsequently described packages, giblets were placed in a parchment bag and included in the package.

After selected periods of frozen storage, comparisons were made between samples held at the various temperature conditions with regard to moisture loss, off odor of the thawed raw meat, and off flavor of deep-fat-fried meat. Organoleptic comparisons were made between −10° F. and the other experimental temperatures, between each of the fluctuating conditions and its steady mean temperature, and in 4-way comparisons between the 0° to +20° fluctuation and the 3 steady temperatures marking the extremes and the mean of the fluctuations. Adequacy of the −10° F. condition as a control is based on lack of important differences between reaction rates at −10° and −30° F. or below.

The data in Table 1 indicate that a storage life of at least one year can be expected under good packaging conditions at a storage temperature of 0° F. or below. Off odors in the raw defrosted meat were detected somewhat earlier than off flavors in the cooked meat. The taste panel was not able to establish significant differences between temperature conditions as easily when 4 samples were compared at a time as when paired comparisons were made. Accordingly, subsequent studies were planned principally in terms of paired comparisons between each experimental temperature and a control.

No significant organoleptic difference developed between samples held under a fluctuating temperature condition and samples held at the mean temperature over extended periods of storage. Hence, for prac-

TABLE 1

Comparative deterioration in well packaged fryers held at various temperatures

Experiment A

Quality evaluated by panel[2]	Months to develop significantly[1] more deterioration at higher (or fluctuating) temperature				
	+20 vs. −10° F.	+10 vs. −10° F.	0 vs. −10° F.	0 to +20 Fluctuation vs. +10° F.	−10 to +10 Fluctuation vs. 0° F.
Odor of raw meat	6	10	>24	>10	24
Flavor of cooked meat	8	18	>24	>10	24

[1] Data represent times in months at which the difference between higher (or fluctuating) temperature and control was significant at a probability level of 5% or less.

[2] Eight trained panel members ranked four replications of each comparison at each storage period.

tical purposes, the deteriorative effect of ordinary temperature variations within the frozen range may be considered equal to the deterioration produced by an equal period at a steady temperature equal to the mean of the variations.

Moisture loss from the package for 10 months' storage is plotted against storage temperature in Figure 2. Loss of about 0.6% moisture at +20° F. produced a moderate degree of visible dehydration or "freezer burn." Loss under the 0° to +20° F. fluctuating condition, which is indicated by the arrow, is equivalent by interpolation to the loss to be expected from a

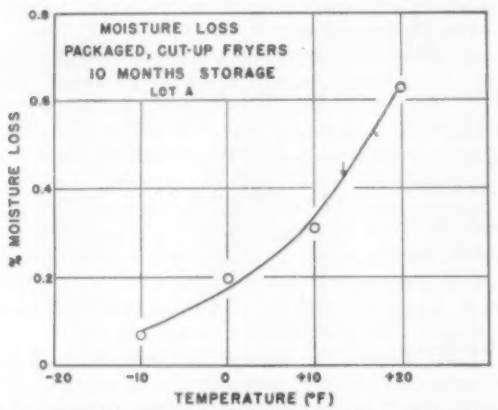

Figure 2. Moisture loss, expressed as per cent of carcass weight, from well packaged cut-up fryers as a function of storage temperature over a ten-month period. The arrow point indicates moisture loss for 0° F. to +20° F. fluctuation, and also the steady temperature with equivalent effect.

steady temperature of +13° F., or 3° above the mean of the fluctuations. This is in reasonable agreement with the theoretically predicted effect of fluctuating temperatures on reactions of constant temperature coefficient *(4, 10)*. The temperature coefficient of the rate of moisture loss, expressed as the ratio of rates at temperatures 10° F. apart, is seen from Figure 2 to be about 2, from which we can theoretically expect *(10)* that the fluctuating condition would be equivalent in effect to a steady +12° F. condition, or 2° F. above the mean. The failure of the organoleptic results to show this effect is not inconsistent since, even with a much larger temperature coefficient, the expected difference would be so small as to be within the experimental error of the taste panel.

Experiment B. *Fryers in inferior commercial package.* This storage test was conducted with fryers, using a commercial package much inferior to that employed in Experiment A. The package consisted of a 1 mil cellophane liner and a telescoping carton with portions of the top cut out to expose writing on the flaps of the inner box. Rate of moisture loss out of this package was approximately ten times that found for the cellophane overwrapped carton used in Experiment A. Birds were processed similarly to those in Experiment A. Paired comparisons of −30° F. controls with birds at the experimental temperature conditions provided data which are illustrated for +20° F. samples in Figure 3 and summarized for all temperature conditions in Table 2. Moisture losses over a 4½ month storage period are plotted in Figure 4 as a function of storage temperature.

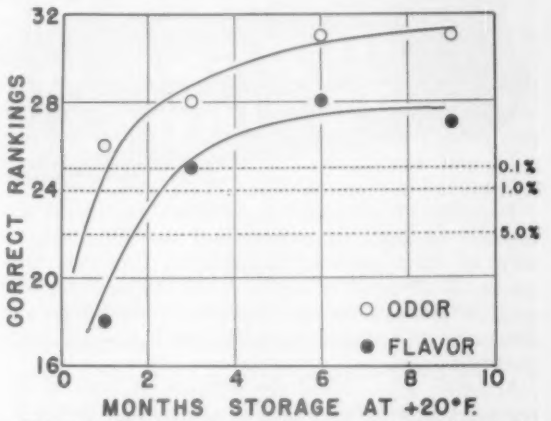

Figure 3. Number of times (out of 32 comparisons) that −30° F. control was ranked over +20° F. sample, for Experiment B involving cut-up fryers in inferior package. Dotted lines indicate number of correct rankings required for three levels of statistical significance.

In comparison with the previous experiment (Exper. A, Table 1) a strikingly greater rate of flavor deterioration, and a correspondingly greater rate of moisture loss, can be noted. It is safe to assume that the greater permeability to moisture vapor was accompanied by greater permeability to the oxygen of the air. Undoubtedly this greater permeability to moisture vapor and air contributed to the greater rate of quality deterioration. The extent of this contribution to the difference in results between Experiments A and B cannot be established exactly, because some of the difference may be due to differences in compositiion or processing treatment of the separate, though typical, commercial lots of chicken.

As also shown in Experiment A, differences in odor

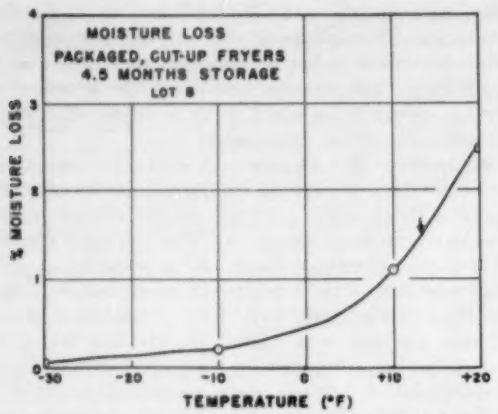

Figure 4. Moisture loss, expressed as per cent of carcass weight, from cut-up fryers in inferior package as a function of storage temperature over a 4½ month period. The arrow indicates moisture loss from 0° F. to +20° F. fluctuation, and also the steady temperature with equivalent effect.

of raw meat were detectable sooner than differences in flavor of cooked meat. The first detectable storage-induced changes in odor were not really objectionable and were described by many as an accentuated typical raw poultry meat odor. It was not a typically rancid odor, and it could not be of bacterial origin because it appeared at temperatures of 0° F. and lower.

Inability of the panel to establish significant differences in flavor of cooked liver was surprising, in view of its recognized instability. However, from comments of panel members it was evident that both controls and experimental samples of liver were suboptimum in texture (crumbly) and possibly other quality factors.

Moisture losses from the inferior package of Experiment B birds were serious (Figure 4), producing appreciable freezer burn on the uppermost surfaces of the cut-up poultry within 4½ months at +10° F. Fluctuation between 0° and +20° F. produced moisture loss that would be expected from a steady temperature of +13° F., or 3° above the mean of the fluctuations. Theoretical calculations *(10)*, based on a temperature coefficient of 2.3 for 10° F. intervals (Figure 4), yield a value of +12° F.

The fluctuating temperature conditions produced detectably more organoleptic deterioration than the steady mean temperature in each case only after the mean temperature had given evidence of a deteriorative effect in comparison with the −30° control. Therefore, since it is only after both samples have developed significant deterioration that the taste panel is able to recognize any inferiority of the fluctuating sample compared to the sample held at the steady mean, this difference in favor of the mean is obviously of no practical importance.

TABLE 2

Comparative deterioration in poorly packaged fryers held at various temperatures

Experiment B

Quality evaluated by panel[2]	Months to develop significantly[1] more deterioration at higher (or fluctuating) temperature					
	+20 vs. −30° F.	+10 vs. −30° F.	0 vs. −30° F.	−10 vs. −30° F.	0 to +20 Fluctuation vs. +10° F.	−10 to +10 Fluctuation vs. 0° F.
Odor of raw meat	<1	3	6	9	3	9
Flavor of cooked meat	3	6	>12	27	>12	>18
Flavor of cooked liver	6	>12	>18	>27	>12	>18

[1] Data represent times in months at which the difference between higher (or fluctuating) temperature and control was significant at a probability level of about 1%.

[2] Eight trained panel members ranked four replications of each comparison at each storage period.

Experiment C. *Fryers in tin cans with controlled atmosphere.* Some fundamental questions on the relative importance of moisture retention and oxygen exclusion are raised by the results of Experiments A and B. In order to develop basic information on the independent effects of oxygen availability, moisture loss, and temperature, commercially processed cut-up fryers were stored in sealed tin cans with atmospheres of nitrogen, air, and nitrogen containing 2.7% oxygen. Some air-packed samples were stored in the presence of a desiccant, calcium chloride, to bring about dehydration without modifying air (oxygen) availability. Other samples were packed in vented cans with ice cubes in contact with meat to provide unlimited availability to air but no significant loss of moisture from the meat. Experimental storage temperatures were +20°, +10°, and 0° F. Nitrogen-packed samples held at −30° F. were used as controls in some comparisons.

The chickens were from a uniform lot of straight-run, 9-week-old, Indian River x Delaware crosses. They were processed to a chilled, cut-up form in a commercial processing plant. Average ready-to-cook weight of the birds was 1100 g. Each bird was packed in a No. 10 tin can of 3000 ml. capacity. For the air-desiccant pack, 100 g. of anhydrous granular calcium chloride were weighed into a paper sack and placed on top of the meat. For the vented cans containing ice, approximately 100 g. of cube ice were added to each can before sealing, and after sealing a ⅛-inch-diameter hole was punched in the can lid.

After periods of storage, ranging from 1 to 16 months and selected according to the estimated stability for a particular temperature-atmosphere condition, the cans were analyzed for oxygen and carbon dioxide content. Moisture loss was measured where appropriate, and paired organoleptic comparisons of raw odor and cooked flavor were made as indicated in Table 3.

Moisture loss out of the vented cans containing ice was in no case more than 0.2% of the weight of the bird, and was probably lost from the ice cubes rather than the meat. Moisture lost by the meat and absorbed by the calcium chloride in the air-desiccant cans (Figure 5) was much greater than the loss experienced in the worst commercial package (Experiment B) and resulted in objectionable amounts of visible surface dehydration. Thus, the two factors, unlimited air and excessive moisture loss, which are linked to-

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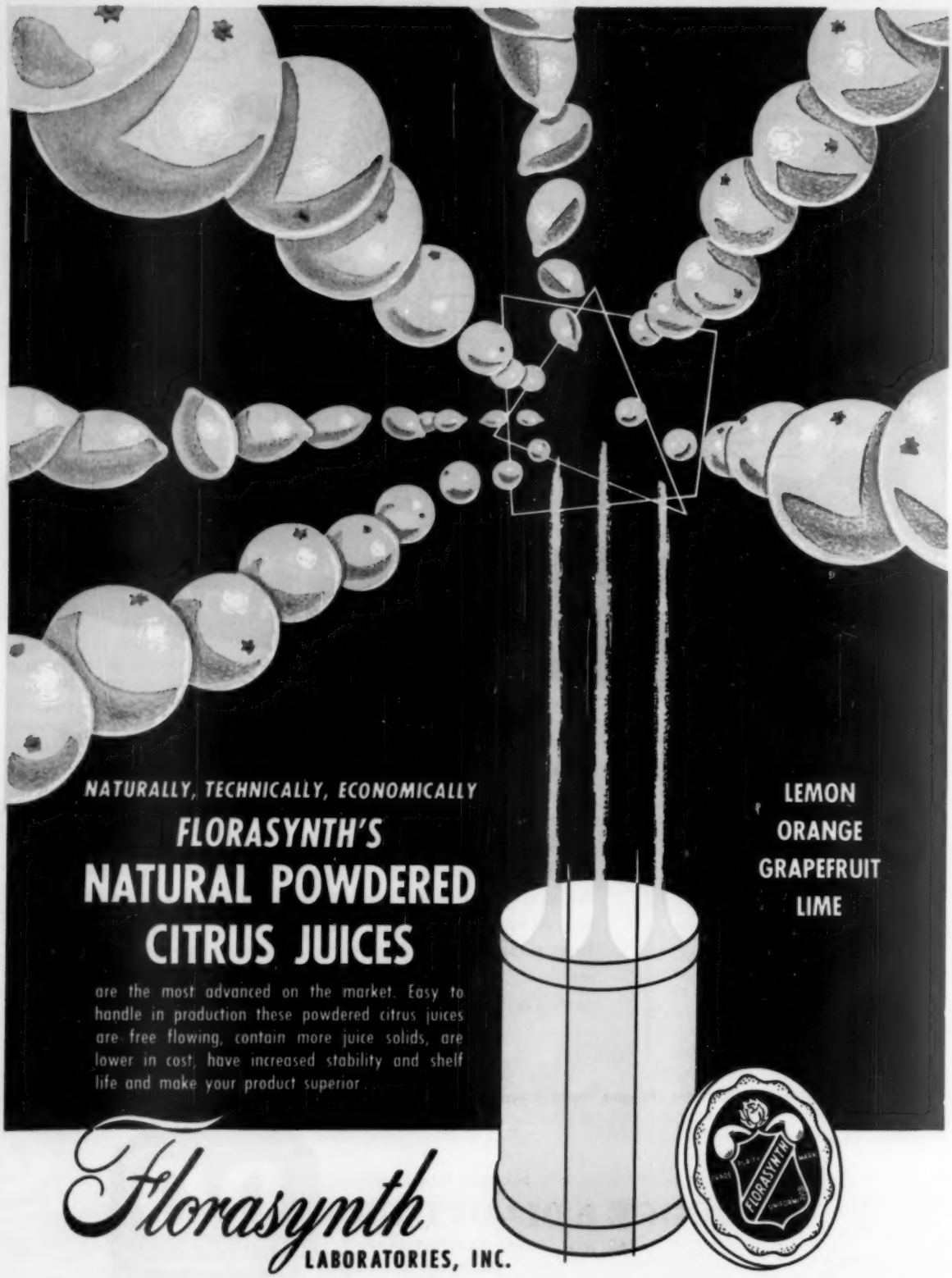
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TABLE 3

Effects of temperature, oxygen, and moisture loss on storage deterioration of fryers
Experiment C

Pairs of temperature-atmosphere combinations compared by taste panel[1]						Months required for detection of significantly[2] worse deterioration in 2nd member of pair								
						Quality								
	1st Member			2nd Member		Odor (raw)			Meat flavor			Liver flavor		
						Exper. temp.			Exper. temp.			Exper. temp.		
	Temp.	Atm.		Temp.	Atm.	+20° F.	+10° F.	0° F.	+20° F.	+10° F.	0° F.	20° F.	10° F.	0° F.
(1)	−30° F.	N_2	vs.	Exper.	AI	½	3	7	4	8	>16	2	4	8
(2)	−30° F.	N_2	vs.	Exper.	N_2	3	7	>16	7	8	12	6	8	>16
(3)	Exper.	N_2	vs.	Exper.	AI	3	6	8	5	10	16	>4	>9	>16
(4)	Exper.	N_2	vs.	Exper.	A	2	5	8	>4	5	12	>4	>9	>12
(5)	Exper.	N_2	vs.	Exper.	2.7% O_2	2	7	12	>4	>7	>12	>4	>7	>12
(6)	Exper.	A	vs.	Exper.	AD	>4	>7	>12	>4	>7	>12	>4	>7	>12

[1] Eight trained panel members ranked four replications of each comparison. Cut-up fryers were packed in sealed tin cans with atmospheres as follows: N_2 — 99.8+% nitrogen; AI — ice in can with ⅛ in. vent to air; A — air; AD — air in presence of desiccant; 2.7% O_2 — mixture of 2.7% oxygen and 97.3% nitrogen. All comparisons were made at three experimental temperatures, +20°, +10°, and 0° F.

[2] Data represent times in months at which panel first ranked the 2nd member of a pair significantly (1% level of probability) worse than the 1st. Times prefixed by a "greater than" > sign represent the times of the last, unsuccessful attempt to detect a significant difference between members of a pair.

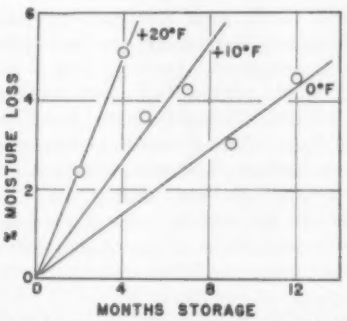

Figure 5. Moisture lost by carcass and absorbed by desiccant in air-desiccant (AD) cans of Experiment C, as related to storage time and temperature.

gether in commercial packages, were effectively separated so that the effect of each could be studied independently.

Oxygen consumption by the meat, as measured by the decrease in oxygen content of the atmosphere in the sealed cans, is shown in Figure 6 for air and air-desiccant packs at the three experimental storage temperatures. Moisture loss does not appear to influence oxygen consumption. Comparison of these rates of consumption with those for the 2.7% oxygen packs, plotted on a two-fold larger scale in Figure 7, indicates that rate of oxygen consumption was markedly decreased by lowering the partial pressure of oxygen in the can.

Production of carbon dioxide, as shown in Figure 8, increased with increase in storage temperature. The predominantly anaerobic nature of this production is indicated by the substantial rates observed in nitrogen packs. Production of carbon dioxide in 2.7% oxygen was about the same as in nitrogen.

Results of organoleptic comparisons of the stored samples are summarized in Table 3 in terms of the time required to develop differences that could be detected by a trained taste panel at a 1% level of statistical significance. The effect of storage temperature on all 3 qualities confirm and further define the relative importance of temperature in preserving quality. The value of holding at 0° F. or below in preventing changes within a year's storage period is at once apparent. Quality deterioration was first detectable in the odor of thawed raw chicken, then in the flavor of cooked liver, and finally in the flavor of cooked meat. As observed in Experiments A and B above, the raw odor was generally described as an intensification of the odor often noticed in processed poultry meat rather than a rancid off odor typical of deteriorated fat. Bitterness was one of the characteristics of off flavor in cooked liver, while stale and/or rancid off flavors were noticed in cooked meat.

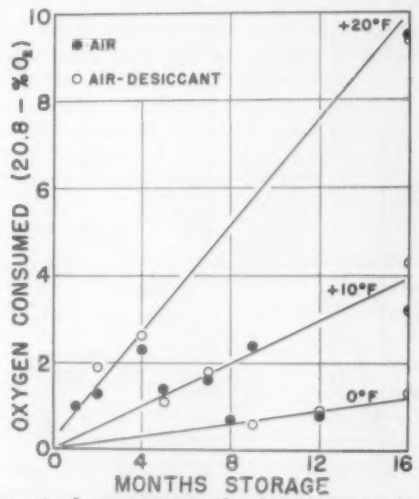

Figure 6. Oxygen consumption by the carcass in air (A) and air-desiccant (AD) cans, as related to storage time and temperature.

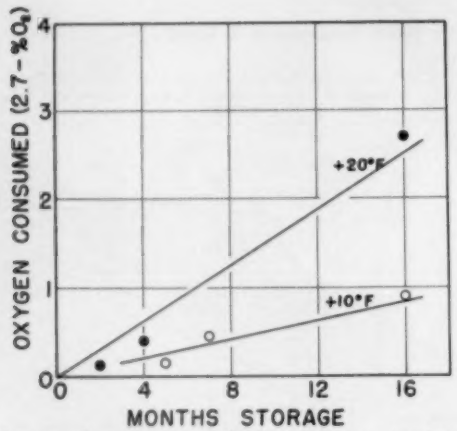

Figure 7. Oxygen consumption by the carcass in atmosphere containing 2.7% oxygen, as related to storage time and temperature.

Comparisons (2) and (3) of Table 3 will be recognized as single variable components of (1) which involves a combined temperature and atmosphere effect. That is, (2) measures the temperature effect independently of air and (3) measures the effect of air at the experimental temperature. Results of these 3 comparisons indicate that a major contribution to deterioration may be attributed to air (oxygen) availability; this is most evident for raw odor and least evident for liver. Inspection of data from comparisons (3), (4), and (5) provides a comparison of the relative deterioration by air in a vented can, air in a sealed can, and 2.7% oxygen in a sealed can. Differences are not great nor are they consistent for all temperatures and quality factors. The vented can with ice provided somewhat longer storage life than did the sealed air packed can. This difference, if real, may be due to loss of volatile off odors (flavors) from the vented can. Deterioration in 2.7% oxygen was not much less than in air (20.8% oxygen), which suggests that gas packing with nitrogen must be essentially complete with no residual oxygen in order to be effective.

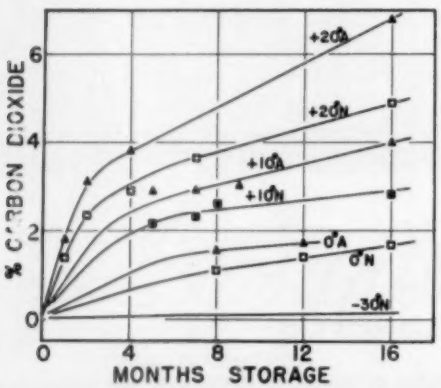

Figure 8. Production of carbon dioxide in atmospheres of air (A) and nitrogen (N), as related to storage time and temperature.

It was of interest to find, from comparison (6) of Table 3, that moisture loss in itself had no measurable effect on odor or flavor deterioration for storage periods in which deterioration due to increased temperature or oxygen availability could easily be demonstrated. This corresponds with the approximately equal oxygen consumptions observed for air and air-desiccant packs in Figure 6. These findings on the relative importance of oxygen and moisture loss are consistent with the results of Cook and White *(1)* and are in agreement with results on ground beef reported by Steinberg *et al. (11)*.

Experiment D. *Stewing hens in fair commercial package.* Since large commercial volumes of fowl or stewing hens are available from laying and breeding flocks, it is important to know the storage characteristics of this type of product. A typical, uniform, commercial lot of individually packaged, cut-up stewing hens (White Leghorns, 2¾ lbs. eviscerated weight) were randomly divided into groups and assigned to experimental temperatures of −30, −10, 0, +10, +20° F., and −10 to +10° F. and 0 to +20° F. fluctuating cycles. Each bird had been processed under normal commercial conditions, cut into 10 pieces, and packed in a commercial package that consisted of a wax paper carton with a flap cover containing a 2½ in. x 5 in. window formed from the 1 mil thick, sheet-cellophane liner. There was no overwrap. Stored samples were evaluated after periods of one to eighteen months for moisture loss, visible dehydration, peroxide values for the raw fat, odor of the raw meat and cooked broth, and flavor of the cooked skin and meat. Stewing hens were cooked by steaming at 212° F. for 2 hours.

Unlike chicken fryers, the stewing hens had appreciable amounts of depot fat in the skin and visceral cavity, which permitted peroxide determinations to be made on the raw fat. Peroxide values, which are rough indices of deterioration, are presented in Figure 9 for stewing hens after 12 months storage at the various temperature conditions. Each point is a mean value derived from 4 to 8 birds, each contributing one sample of skin fat and one of visceral fat. Values of 10 meq./kg. or more are generally considered to indicate a significant degree of rancidity. Arrows in Figure 9 indicate the peroxide values obtained under the two fluctuating temperature conditions, and also show through interpolation the approximate steady temperature required to give the same peroxide value as that produced by the fluctuating temperature. The −10 to +10° F. fluctuation was equivalent in effect to a steady +7° F., the 0 to +20° F. fluctuation to a steady +14° F. The ratio of rates of peroxide development at steady temperatures 10° F. apart is approximately 3, from which it may be calculated theoretically *(10)* that the effective temperature for fluctuating conditions should be about 3 degrees above the mean temperature in each case. The greater increments observed (7° and 4°) may be expressions of the large experimental variability in peroxide development within groups

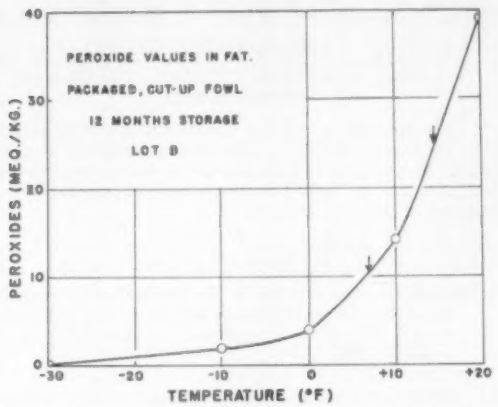

Figure 9. Peroxide development in raw fat of packaged cut-up stewing hens during one year's storage, as a function of storage temperature. Two arrows, from left to right, indicate peroxide values for (−10 to +10° F.) and (0 to +20° F.) fluctuations, respectively; and also indicate the equivalent steady temperatures.

due to variation in size and relative exposure of fat depots.

Percentage moisture loss from packages of cut-up stewing hens was essentially a linear function of storage time over the 16-month experimental period for each of the temperature conditions studied. Data for 16 months' storage, as plotted in Figure 10, show the temperature effect and specifically the effect of a fluctuating temperature in relation to the steady mean temperature. The −10° to +10° F. fluctuation was equivalent to +2° F. steady temperature, and the 0° to +20° F. was equivalent to +14° F. steady temperature. These increments over the mean agree roughly with values obtained with turkeys in a poor package *(5)*. Calculated from the observed temperature coefficient (for a 10° F. differential) of 1.8, the theoretical expected increment is about 1.5°.

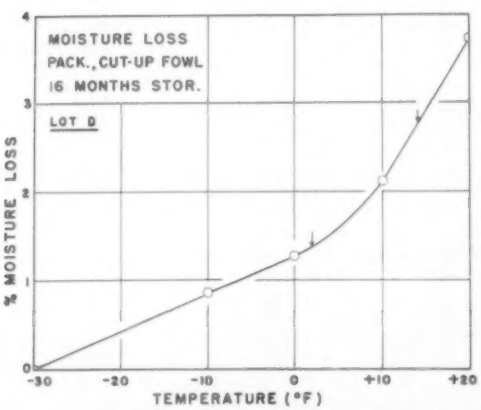

Figure 10. Effect of storage temperature on moisture loss from packaged, cut-up stewing hens after 16 months' storage. Two arrows, from left to right, indicate moisture losses for fluctuations from −10° to +10° F. and from 0° to +20° F., and also indicate the equivalent steady temperatures. Moisture loss is expressed as a percentage of carcass weight.

TABLE 4

Comparative deterioration in packaged cut-up stewing hens held at various temperatures

Experiment D

Quality evaluated by panel[2]	Months to develop significantly[1] more deterioration at higher (or fluctuating) temperature					
	+20 vs. −10° F.	+10 vs. −10° F.	0 vs. −30° F.	−10 vs. −30° F.	0 to +20 Fluctuation vs. +10° F.	−10 to +10 Fluctuation vs. 0° F.
Odor of raw meat	3	6	9	18	9	>18
Flavor of cooked meat	4	7	>12	>18	12	>18
Flavor of cooked skin	4	7	12	>18	9	>18
Odor of cooked broth	5	6	12	>18	>12	>18

[1] Data represent times in months at which the difference between the two indicated temperature conditions was significant at a probability level of about 1%.

[2] Six to 7 trained panel members ranked 4 replications of each comparison at each storage period.

Results of organoleptic evaluation, as summarized in Table 4, indicate a high-quality storage life of 3, 6, 9, and 18 months at +20, +10, 0, and −10° F., respectively. Off odors were detected before off flavors. The fluctuating (0 to +20) temperature condition produced a little greater deterioration than the steady mean (+10°) temperature, but the difference was not detected during the normal storage life of either group and hence is of no practical importance.

General comparisons and correlations among 4 storage tests. While the 4 experiments represent 4 different and in some respects dissimilar lots of chicken, it is of interest to compare results and explore potential bases for the differences. The relative permeabilities of the 3 commercial packages used in Experiments A, D, and B are roughly indicated by the percentages of moisture loss after 4 months at +20° F., which were 0.2, 1.0, and 2.0, respectively. The rate of moisture loss shows an inverse relation to the storage life at +20° F., which was 6, 3, and 1 month, respectively. This raises the question whether the observed relation between moisture permeability and rate of deterioration is direct cause and effect or just a reflection of probable correlation between moisture permeability and oxygen permeability or other critical factors varying among the 3 experiments. Comparisons set up in Experiment C by use of tin cans provided some answers to this question. In sealed cans, an induced rate of moisture loss greater than that experienced in the worst commercial package failed to influence rate of organoleptic deterioration. However, markedly greater rates of deterioration were obtained in air packs over nitrogen packs, or even in packs containing 2.7% oxygen compared to nitrogen packs. If we wish to explain the large differences between the 3 commercial packs on the basis of our results with fryers in tin cans, we must assume a surprisingly low oxygen availability in the best overwrapped package. In addition to well-sealed, tear-free, impermeable film overwraps, the assurance of solidly packed, com-

pletely filled cartons should also help to attain a low oxygen content.

Storage-induced change in the gizzards was manifested by a change in color of cooked tissue from blue-black to red. The reddish color, which was observed on slicing the boiled gizzard, was always evident by the time that significant organoleptic deterioration of the carcass had occurred. Origin or significance of this color change is not known.

SUMMARY AND CONCLUSIONS

Frozen-storage tests were carried out on 2 commercial packs of cut-up chicken fryers differing in type and adequacy of package, one experimental pack of cut-up fryers in tin cans, and one commercial pack of cut-up stewing chickens. Evaluations were made of moisture loss, peroxide development, off odors in raw meat, and off flavors in cooked product.

Slight off odor in thawed raw meat was the first quality defect to be detectable, followed by off flavors in cooked products. Chickens from all packaging conditions had a high-quality storage life of at least 6 months at 0° F. However, there were large differences in stability between the 2 commercial packs of fryers, that were to a great extent reflections of the large difference in package permeability. Chickens in the more permeable package had less than one-third of the storage life of chickens in the less permeable package. Stewing hens held in a package of permeability intermediate between that of the 2 fryer packages had a corresponding intermediate storage life. Peroxide development in fat of stewing hens was correlated with the level of organoleptic deterioration.

A storage test of cut-up fryers in tin cans with controlled atmospheres was used to establish independently the deteriorative effects of oxygen (air) availability and moisture loss. Moisture loss in itself was found to have little effect on organoleptic deterioration or chemical changes involving oxygen consumption. Access to oxygen of the air, on the other hand, contributed as much to rate of deterioration as a substantial rise in temperature. Appreciable deterioration and carbon dioxide production in nitrogen packs indicated that anaerobic reactions are also involved.

Tests at +20°, +10°, 0°, −10°, and −30° F. provided evidence to support a recommendation for storage at 0° F. or below. Storage life at +20° F. ranged from less than one month to 6 months for the various packaging conditions, at +10° F. from 3 to 10 months, while at 0° F. storage life was at least 6 months in the poorest package and about 2 years in the best package. Within reasonable storage periods, a series of temperature fluctuations had practically the same (only slightly greater) deteriorative effect on quality as a steady temperature equal to the arithmetic mean of all of the fluctuations.

The results emphasize that statements on storage life, to have real value, must accurately define the intimate product environment as governed by packaging as well as by temperature conditions.

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Control of Exudation in Prepeeled French-Fry Potatoes with Antibiotics[a, b]

F. J. Francis, B. L. Amla and A. Kiratsous

University of Massachusetts, Amherst, Massachusetts

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THE CONVENIENCE FACTOR associated with prepeeled potatoes has led to their use in a number of commercial establishments. One estimate *(2)* indicated that over 5,000,000 bushels were marketed in the prepeeled form in 1955. However, lack of quality control in the handling procedure has led to excess sulphite residues and other problems, and a number of establishments who have tried prepeeled potatoes have discontinued them. Another problem, apart from sulphite residues, is the accumulation of liquid exuded by the peeled potatoes in storage. Aside from being unsightly and unsanitary, the degree of exudation is directly related to the loss of turgor of the potato cells and thus to the subsequent softening of the potato tissue. Soft potatoes are undesirable from a culinary standpoint.

The present investigation was undertaken to study the possibility of reducing the amount of exudation by incorporating an antibiotic into the sulphite solutions. On the hypothesis that the exudation is caused in part by an increased permeability of the cell walls due to the growth of microorganisms, it seemed logical to expect that an antibiotic treatment might be effective.

MATERIALS AND METHODS

Potatoes used in this study were obtained through regular commercial channels as required and were processed at the time indicated in each table.

Preliminary experiments indicated that abrasion peeling introduced small bruises which made the degree of exudation more variable. Consequently, in this experiment, the potatoes were hand peeled in order to reduce the number of replicates necessary to get the same accuracy in the treatments.

Potatoes were peeled as required and held under cold water until they could be cut into French-Fry style strips and processed. After cutting, the strips were dipped for 30 seconds in the appropriate solution, drained, and packed into polyethylene[c] or Cryovac bags.[d] The air in the Cryovac bags was exhausted (15 inches of vacuum) and the bags were sealed with a metal clip using a commercial Cryovac closing machine. The polyethylene bags were treated similarly except that the air in the bags was not exhausted. Two hundred grams of potatoes were packed in each bag and duplicate bags were packed for each treatment.

The amount of exudation was determined by blotting the strips and bag with a paper towel. The weight of the dry towel subtracted from the weight of the damp towel gave a measure of the amount of exudation.

The antibiotics used were obtained in the form of Biostat[e] for oxytetracycline, the crystalline hydrochloride salt for chlortetracycline[f] and a preparation containing 20% active material for polymixin.[e] The phytic acid and calcium phytate solutions were made by diluting stock solutions of 70% phytic acid[g] and 50% calcium phytate[g] respectively. In the treatments involving antibiotics and other chemicals, the compounds were added directly to the sulphite solutions.

The data in Tables 7, 8 and 9 were obtained with potatoes cut into one inch cubes rather than French-Fry style strips in order to facilitate the color measurements *(1)*. When potatoes were cut into French-Fry strips of one-half inch size and measured on a Gardner Color-Difference Meter[h] equipped with small area illumination and a one-half inch aperture, there was some loss of light through the sides of the strips. This resulted in lower "b" values. This difficulty was avoided by using one-inch cubes which had a larger surface area.

The alcohol determinations were made, in duplicate, by the method of Shupe and Dubowski *(4)*. The softness determinations were made with a Universal Precision Penetrometer[i] with 150 g. weight on the bar. With this method, a higher reading indicated a softer tissue.

The Sequential Least Significant Differences in Table 4, were calculated by the method of Hartley as reported by Snedecor *(5)*. The Least Significant Differences in Tables 7 and 8 were calculated by the method of Link and Wallace *(5)*.

RESULTS AND DISCUSSION

The extent and rate of exudation in prepeeled potatoes are governed apparently by a number of factors. One of these is the time of storage after dipping. The exudation as measured by surface moisture was high immediately after packing as the strips were quite wet. However, normal healthy potato tissue will absorb the surface moisture quite rapidly as illustrated in Table 1, where most of the liquid was absorbed within the first 4 hours. Then as the storage period is lengthened and the microbiological population increases, the potato strips reach the point where the tissues begin to give up liquid and the exudation starts to increase. Soon after this stage, the exudation increases rapidly and the potatoes are near the end of their shelf life.

It might be expected that the amount of exudation would depend on the liquid uptake of the strips during processing as potato strips can be made to take up as much as 40% water *(3)*. In Table 2, even when potatoes were immersed for 128 minutes and took up

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[a] Contribution No. 1196 from the Department of Food Technology, University of Massachusetts Agricultural Experiment Station, Amherst, Mass.

[b] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, May 19, 1959.

[c] The 2 x 4 x 12 in. bags of one mil polyethylene were obtained through the courtesy of the Shellmar-Betner Division of the Continental Can Co., Newark, Ohio.

[d] The 5 x 16 in. bags were obtained through the courtesy of the Cryovac Division of the W. R. Grace & Co., Cambridge, Mass. Cryovac is a trade name for a film made from a copolymer of vinylidene chloride and vinyl chloride.

[e] Obtained through the courtesy of Chas. Pfizer & Co., Inc., Brooklyn, N. Y.

[f] Obtained through the courtesy of the American Cyanamid Co., Pearl River, N. Y.

[g] Obtained through the courtesy of the A. E. Staley Co., Decatur, Ill.

[h] Manufactured by the Henry A. Gardner Co., Bethesda 14, Md.

[i] Obtainable from the A. S. Aloe Co., St. Louis 3, Mo.

TABLE 1

Exudation in prepeeled potatoes[1] at intervals after packing

Storage time at 50° F.	Exudation
Hours	%
0	1.48
2.5	1.12
2.7	0.93
2.9	0.80
3.0	0.70
3.5	0.45
3.7	0.35
24.0	0.26

[1] French-Fry style strips made from Maine Russet Burbank potatoes in March, 1958. The strips were treated with 2000 p.p.m. sulphur dioxide as sodium bisulphite, 10 p.p.m. oxytetracycline, and packed in polyethylene bags.

TABLE 2

Liquid uptake and exudation in prepeeled potatoes[1] with different times of immersion in water

Duration of dip	Liquid uptake	Exudation after 6 days at 50° F.
Minutes	%	%
1	1.0	0.17
2	0.9	0.06
4	1.7	0.06
8	1.2	0.13
16	1.7	0.05
32	2.9	0.14
64	6.1	0.21
128	10.3	0.36

[1] The Maine Russet Burbank French-Fry strips were dipped for 30 seconds in a solution of 500 p.p.m. sulphur dioxide as sodium bisulphite after the indicated immersion time in water and packed in Cryovac bags in March, 1958.

10% water, the degree of exudation was not appreciably increased. However, this experiment was performed under relatively sanitary conditions. It would be expected that if the microbiological population on the potatoes were higher, the exudation would be greater when the potatoes had been allowed to absorb much liquid. However, this factor is not likely to be of commercial importance as potatoes are seldom held under water for any period of time.

Effect of antibiotics on exudation. In Table 3, data are presented on the effect of oxytetracycline on exudation in potato strips stored at 38° F. in polyethylene and Cryovac bags. The exudation decreased

TABLE 3

Exudation in prepeeled potatoes treated with oxytetracycline

Storage time	Concentration of oxytetracycline—p.p.m.						
	0	2	5	10	15	25	50
	Exudation—%						
Days at 38° F.[1]	Polyethylene bags[2]						
1	1.63	.....	1.50	1.36	.....	1.47	1.08
2	1.08	.....	1.18	1.09	.....	1.15	0.73
4	0.63	.....	0.90	0.62	.....	0.55	0.39
6	0.84	.....	0.98	0.54	.....	0.41	0.41
8	0.63	.....	0.47	0.39	.....	0.46	0.29
10	0.55	.....	0.50	0.46	.....	0.47	0.27
12	0.53	.....	0.41	0.30	.....	0.32	0.23
	Cryovac bags[3]						
1	3.11	.....	0.49	0.62	.....	0.78	0.58
2	2.88	.....	0.59	0.43	.....	0.44	0.53
4	2.60	.....	0.42	0.51	.....	0.41	0.59
6	2.07	.....	0.47	0.55	.....	0.64	0.54
8	2.50	.....	0.32	0.51	.....	0.41	0.38
10	2.05	.....	0.68	0.51	.....	0.48	0.39
12	2.72	.....	0.78	0.56	.....	0.48	0.44
Days at 50° F.[4]	Polyethylene bags[2]						
0	1.60	1.60	1.60	1.60	1.60	1.60	.....
1	0.29	0.32	0.36	0.53	0.48	0.35	.....
2	0.27	0.29	0.26	0.21	0.30	0.44	.....
4	0.04	0.04	0.03	0.02	0.03	0.10	.....
7	0.31	0.30	0.28	0.18	0.40	0.19	.....
10	1.48	0.85	0.97	0.31	0.98	0.81	.....
	Cryovac bags[3]						
0	1.62	1.62	1.62	1.62	1.62	1.62	.....
1	0.06	0.09	0.04	0.09	0.15	0.18	.....
2	0.10	0.25	0.14	0.33	0.25	0.05	.....
4	0.03	0.03	0.03	0.02	0.07	0.04	.....
7	0.43	0.18	0.06	0.05	0.10	0.10	.....
10	Decayed	1.21	0.15	0.20	0.05	0.16	.....

[1] Russet Burbank variety (Long Island, N. Y.) French-Fry strips treated in August, 1957.
[2] The strips were treated with 2000 p.p.m. sulphur dioxide as sodium bisulphite.
[3] The strips were treated with 500 p.p.m. sulphur dioxide as sodium bisulphite.
[4] Russet Burbank variety (Maine) French-Fry style strips treated in February, 1958.

with storage time probably because at this temperature the microbiological population had not started to increase rapidly. The exudation also decreased with increasing concentration of the antibiotic within the limits of this experiment.

The experiment illustrated in Table 3 was repeated for chlortetracycline and polymixin with essentially

TABLE 4

Average exudation of sulphited prepeeled potatoes[1] treated with antibiotics

Antibiotic	Storage at 38° F.	Concentration of antibiotic—p.p.m.				
		0	5	10	25	50
	days	Exudation—%				
Polyethylene bags[2]						
Oxytetracycline	12	0.79	0.78	0.67	0.61	0.43
Sequential L.S.D.'s are 0.21, 0.20, 0.18 and 0.15						
Chlortetracycline	12	0.79	0.68	0.49	0.33	0.28
Sequential L.S.D.'s are 0.16, 0.15, 0.13 and 0.11						
Polymixin	8	0.87	0.82	0.62	0.45	0.43
Sequential L.S.D.'s are 0.22, 0.20, 0.18 and 0.15						
Cryovac bags[3]						
Oxytetracycline	8	2.43	0.42	0.46	0.48	0.50
Sequential L.S.D.'s are 0.66, 0.61, 0.54 and 0.44						
Chlortetracycline	8	2.43	0.36	0.37	0.34	0.32
Sequential L.S.D.'s are 0.90, 0.84, 0.75 and 0.60						
Polymixin	8	2.43	0.46	0.56	0.63	0.78
Sequential L.S.D.'s are 0.32, 0.29, 0.27 and 0.22						

[1] Russet Burbank variety (Long Island, N. Y.) French-Fry strips treated in August, 1957.
[2] The strips were treated with 2000 p.p.m. sulphur dioxide as sodium bisulphite.
[3] The strips were treated with 500 p.p.m. sulphur dioxide as sodium bisulphite.

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similar results as shown in Table 4. Averages reported in Table 4 for oxytetracycline and chlortetracycline in polyethylene bags are based on duplicate determinations on each of 12 days. Data for the odd-numbered days were left out of Table 3 in the interests of brevity. Averages for polymixin in Table 4 were calculated for the first 8 days only as a slimy condition developed with longer storage times. Polymixin cannot be recommended for potatoes for this reason.

It is apparent from Table 4 that 10 p.p.m. of either oxytetracycline, chlortetracycline, or polymixin in the sulphite solution was sufficient to reduce the exudation markedly when the potato strips were stored in polyethylene bags. The data were analyzed in order to test whether the 3 antibiotics differed in their ability to reduce exudation when applied at the 10 p.p.m. level. An analysis of covariance was chosen because the data showed an obvious regression with time of storage and the difference between the antibiotics were not significant at the 0.05 level. All three were apparently equally effective within the limits of this experiment.

Data in Tables 3 and 4 indicate that the antibiotics were also effective in reducing exudation when the potatoes were stored in Cryovac bags. Cryovac bags have a much lower rate of gaseous transmission than polyethylene bags and this apparently shows up in the degree of exudation because the controls in Cryovac bags consistently showed more exudation. However, the antibiotic treatment at even 5 p.p.m. reduced the exudation to that found in polyethylene bags. In Table 4, the average value for each level of the antibiotics for the first 8 days of storage is presented. Again a simple analysis of variance for the data at 5 p.p.m. indicated that the 3 antibiotics did not differ in their ability to reduce exudation.

In Table 3, data are also presented on the extent of exudation of potato strips stored at 50° F. The experiment was repeated with chlortetracycline with essentially similar results. At this temperature, the shelf life was much shorter but both antibiotics were equally effective in reducing exudation.

In Table 5, data are presented on the effect of oxytetracycline on the extent of exudation in potato strips with a higher microbiological population. The container of potato strips in water was inoculated with a bag of potato strips from the controls of a previous lot stored under the same conditions. The contents of the bag, which had been allowed to spoil, were agitated for one minute in a Waring blender before being added to the stock pot. In this experiment, the controls had a very short shelf life but the antibiotic was effective in reducing exudation and prolonging the shelf life but not to the extent possible with potatoes packed under sanitary conditions. It is well known, of course, that the antibiotics are generally most effective in prolonging shelf life when the initial microbiological population is very low.

It was reported in a previous paper *(1)* that phytic acid or calcium phytate could replace part of the sulphur dioxide for the control of discoloration. Both additives are ineffective in themselves but can be used in conjunction with salts of sulphur dioxide. The data in Table 6 are included here because the addition of excess phytic acid or calcium phytate can produce excessive exudation due presumably to chemical injury. This injury shows up as a greater content of alcohol and more exudation. In Table 7, data are presented on the effects of the same chemicals when the potatoes were stored in Cryovac bags. Here the alcohol contents were higher even though the concentra-

TABLE 5

Exudation in prepeeled potatoes[1] treated with oxytetracycline and sodium bisulphite and inoculated with spoilage organisms from a previous pack

Storage at 50° F.	Concentration of oxytetracycline—p.p.m.					
	0	2	5	10	15	25
days	Exudation—%					
	Polyethylene bags[2]					
0	2.24	2.24	2.24	2.24	2.24	2.24
1	.....	0.65	0.82	0.87	0.30	0.42
2	2.51	0.96	0.50	0.49	0.42	0.44
4	Decayed	Decayed	1.37	1.38	0.60	0.69
6	Decayed	Decayed	Decayed	Decayed	Decayed	0.91
8	Decayed	Decayed	Decayed	Decayed	Decayed	Decayed
	Cryovac bags[3]					
0	2.24	2.24	2.24	2.24	2.24	2.24
1	0.35	0.19	0.25	0.28	0.13	0.21
2	0.25	0.13	0.10	0.19	0.08	0.08
4	0.31	0.15	0.06	0.06	0.03	0.03
6	Decayed	0.26	0.18	0.11	0.03	0.06
8	Decayed	0.87	0.54	0.67	0.06	0.04

[1] French-Fry style strips made from Maine Russet Burbank variety in March, 1958.
[2] The strips were treated with 2000 p.p.m. sulphur dioxide as sodium bisulphite.
[3] The strips were treated with 500 p.p.m. sulphur dioxide as sodium bisulphite.

TABLE 6

Exudation, alcohol content, and discoloration of prepeeled potatoes[1] treated with solutions of oxytetracycline, phytic acid, calcium phytate and sodium bisulphite and packed in polyethylene bags

Treatment[2]	Exudation visual	Alcohol mg./100 g.	Discoloration. "Rd" value
Oxytetracycline, 50 p.p.m. plus phytic acid, 2.1%	0[3]	2.0	36.7
plus SO_2, 500 p.p.m.	0	<2.0	39.3
1000 p.p.m.	+	49.5	46.1
Oxytetracycline, 50 p.p.m. plus phytic acid, 0.7%	0	<2.0	38.8
plus SO_2, 500 p.p.m.	0	13.5	40.4
1000 p.p.m.	0	13.0	45.6
L.S.D., 0.05 level, for 6 treatments			2.35
Oxytetracycline, 50 p.p.m. plus calcium phytate, 1.5%	0	<2.0	38.8
plus SO_2, 500 p.p.m.	0	<2.0	39.0
1000 p.p.m.	++	87.0	46.8
Oxytetracycline, 50 p.p.m. plus calcium phytate, 0.5%	0	<2.0	38.6
plus SO_2, 500 p.p.m.	0	<2.0	45.7
1000 p.p.m.	+	16.5	41.4
L.S.D., 0.05 level, for 6 treatments			3.23
Oxytetracycline, 50 p.p.m.	0	<2.0	35.8
plus SO_2, 500 p.p.m.	0	<2.0	47.8
1000 p.p.m.	0	<2.0	43.8
Controls, no treatment	0	<2.0	35.9

[1] Cubes made from California Long White type potatoes in August, 1957, stored for 16 days at 40° F.
[2] The remainder of the treatments in this series, e.g., phytic acid, calcium phytate and sulphur dioxide alone were presented in reference *(1)*.
[3] 0 = none, + = moderate, ++ = severe exudation.

TABLE 7

Exudation, softening, alcohol content, and discoloration of prepeeled potatoes[1] treated with solutions of oxytetracycline, phytic acid, calcium phytate and sodium bisulphite and packed in Cryovac bags

Treatment[2]	Exudation visual	Softness Penetrometer	Alcohol mg./100 g.	Discoloration "Rd" value
Oxytetracycline, 50 p.p.m. plus phytic acid, 1.4%	0[3]	35.2	98	38.1
plus SO_2, 200 p.p.m.	0	32.2	86	46.0
400 p.p.m.	0	33.3	4	46.1
Oxytetracycline, 50 p.p.m. plus phytic acid, 0.7%	0	33.0	10	35.8
plus SO_2, 200 p.p.m.	0	33.2	71	46.2
400 p.p.m.	0	33.5	89	44.9
Oxytetracycline, 50 p.p.m. plus phytic acid, 0.35%	0	36.3	59	37.0
plus SO_2, 200 p.p.m.	0	37.8	22	48.3
400 p.p.m.	0	41.0	33	43.6
L.S.D., 0.05 level, for 9 treatments		4.01		3.14
Oxytetracycline, 50 p.p.m. plus calcium phytate, 1.0%	0	35.2	96	40.2
plus SO_2, 200 p.p.m.	0	34.1	105	46.1
400 p.p.m.	0	37.0	85	44.5
Oxytetracycline, 50 p.p.m. plus calcium phytate, 0.5%	0	34.0	75	38.0
plus SO_2, 200 p.p.m.	0	31.7	84	47.1
400 p.p.m.	0	34.3	82	46.0
Oxytetracycline, 50 p.p.m. plus calcium phytate, 0.25%	0	32.0	50	37.3
plus SO_2, 200 p.p.m.	0	32.7	59	45.1
400 p.p.m.	0	33.7	89	45.6
L.S.D., 0.05 level, for 9 treatments		4.21		3.28
Oxytetracycline, 50 p.p.m.	0	38.2	60	36.1
plus SO_2, 200 p.p.m.	0	37.3	50	37.6
400 p.p.m.	0	40.5	70	44.8
Controls, no treatment	++	51.0	55	37.4

[1] Cubes made from California Long White type potatoes in August, 1957, and stored for 16 days at 40° F.

[2] The remainder of the treatments in this series, e.g. phytic acid, calcium phytate and sulphur dioxide alone were presented in reference *(1)*.

[3] 0 = none, + = moderate, ++ = severe exudation.

tion of the chemicals were lower presumably due to the effect of a greater degree of anaerobic respiration. In Table 8, the overall effects of oxytetracycline on discoloration, alcohol content and softness are presented. It will be seen that the antibiotic had little effect on discoloration but did lower the content of alcohol and produced firmer potatoes. It may be that the chemical treatment made the potato cells less able to withstand the effects of the microorganisms and the antibiotic was able to exert a protective effect by delaying their growth.

The full significance of the protective effect of the antibiotics on prepeeled potatoes is not clear at the present time. Certainly, in terms of alcohol content, which in itself is related to the degree of chemical injury, the extent of anaerobiosis and the micro-

TABLE 8

Summary of data on effect of oxytetracycline on discoloration, softening and alcohol content of prepeeled potatoes

	With oxytetracycline[1]		Without oxytetracycline[2]	
	Phytic acid	Calcium phytate	Phytic acid	Calcium phytate
Discoloration ("Rd" value)				
Cryovac	42.9	43.4	43.2	42.8
Polyethylene	40.8	41.7	40.4	38.9
Alcohol (mg./100 g.)				
Cryovac	52	81	73	90
Polyethylene	14	21	32	26
Softness (Penetrometer)				
Cryovac	35.1	33.9	39.7	35.1

[1] Data taken from Tables 6 and 7 of this publication.

[2] Data taken from Tables 3, 4 and 5 of reference *(1)*.

biological population, the protective effect is rather complicated. However, it may be possible to derive a quality index for prepeeled potatoes based in part on alcohol content when more is known about the physiology of this phenomenon.

SUMMARY AND CONCLUSIONS

The exudation of liquid from prepeeled potatoes on storage is undesirable because it reduces the shelf life of the product and produces an unsightly and unsanitary appearance. It can be minimized by adding 10 p.p.m. of oxytetracycline or chlortetracycline to the sulphite dipping solution for French-Fry style strips packed in polyethylene bags. Five p.p.m. of either antibiotic was effective for French-Fry strips in Cryovac bags. Both antibiotics were equally effective at 38° F. and at 50° F. but the shelf life was much shorter at the higher temperature. Oxytetracycline was effective in reducing exudation and extending shelf life even with potato strips inoculated with spoilage organisms from a previous pack. Oxytetracycline also exerted a protective effect as shown by lower alcohol content and firmer potatoes when the strips had undergone some chemical injury due to treatment with an excess of sulphite and phytic acid or calcium phytate.

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Effect of Sugar, Storage Time and Temperature on Dill Pickle Quality[a]

(Manuscript received March 13, 1959)

Rose Marie Pangborn, Reese H. Vaughn, George K. York II, and Marlene Estelle

Department of Food Science and Technology, University of California, Davis, California

As reported previously *(5)*, the flavor quality of processed dill pickles was significantly improved by the addition of small amounts of sucrose. This paper considers the quality changes in dill pickles as influenced by sugar, storage time, and temperature.

METHODS AND MATERIALS

Preparation. Pickles evaluated in this investigation were packed under standard commercial conditions by the Farm Foods Co., Inc., Ceres, California. A 300 gal. tank was filled with size-graded cucumbers to 2/3 capacity (approx. 1,668 lbs.) and covered with approximately 100 gal. of brine. The splash brine contained 32 oz. vinegar (120 grain) and had a salt content of 38° salometer (3.8° salometer = 1% salt at 60° F.). Spicing added to the brine included 23 lbs. brined and dried dill weed and 5 lbs. pickling spices[b]. The salt content was equalized at 20° salometer.

Processing was done on October 28, at which time pickles of approximately 1,800 count per 45 gal. were packed cold into 1 pint glass jars and covered with fresh, spiced brine. Sugar additions were made, filled containers were capped with screw-type lids, and pasteurized at 160° F. for 45 min. The processed product was then cooled in water to 95° F. Originally, the addition of sucrose to levels of 0, 1, 2, and 3% were ordered, but through a misunderstanding, the pack delivered contained sugar levels of 0, 2, and 4%. An analysis of the pickle brine (2, 3) gave reducing sugar values (after inversion) of 0.10, 1.45, and 4.60 g./100 ml., respectively.

Before evaluations were initiated, a period of 4 weeks elapsed to allow for equilibration of the sugar with the pickles. December 1 was designated as "0 time" for testing the first group of pickles. The remainder were subdivided and placed in storage at temperatures of 34, 70, 86, and 98° F. (± 2° F.). Subsequent testing periods occurred after 4, 8, 16, and 32 weeks of storage.

Objective measurements. Total acidity, volatile acidity, salt content, pH, texture, and color measurements were determined in the same manner as described previously *(5)*. Vacuum of the capped jars was also measured[c]. In addition, the soluble solids of the pickle brine were determined by refractometry and recorded as degrees Brix.

Subjective measurements. A laboratory taste panel of 12 trained members judged texture, color, pickling flavor, presence of undesirable flavors, and gave their over-all reaction. A balanced, incomplete block design described by Cochran and Cox *(1)* was used wherein 3 samples were judged per session using the score card described previously *(5)*. A total of 20 separate evaluations was obtained for each pickle sample. Each day, all 16 samples of pickles were judged for color acceptability under a standard light source[d] by each panel member. The remaining subjective measurements were done in individual, partitioned booths where red illumination effectively masked color differences between samples. Water and unsalted crackers were provided to eliminate carry-over of any off-flavors and to prevent taste fatigue.

RESULTS AND DISCUSSION

Effect of sugar. Flavor was affected by sugar more than by time or temperature of storage (Tables 2 and 3; Figure 1). At the onset of the study, samples designed at 0 and 2% were equally well liked and considered superior to the 4% sample which was too sweet (Table 1). As the study continued, the sample containing 2% sugar emerged as the most desirable in flavor, texture, color, and over-all acceptability. A similar observation was made in a previous study *(5)* where 2% sugar enhanced pickling flavor of processed dill pickles.

The data suggest that the sugar might have aided in protecting the pickles against adverse color changes which occurred with time at storage temperatures of 34° and 86° F. (Figure 2). Statistical analysis of the complete data (Table 3) showed that the effect of sugar on flavor, undesirable flavor, and over-all reaction was significant at the 0.1% level of probability. Sugar affected texture to a very slight extent (Tables 2 and 3).

There were no significant statistical interactions of sugar with time or temperature (Table 3). Shear-

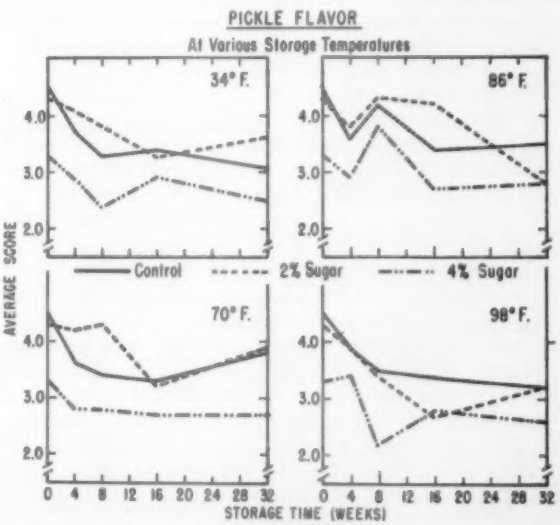

Figure 1.

[a] Supported in part by the National Pickle Packers Association and the Sugar Research Foundation, Inc.

[b] Formula prepared by W. J. Stange Co., Oakland, Calif.

[c] Budenberg F.I.R.A. canned products vacuum gauge. Budenberg Gauge Co., Ltd., Broadheath.

[d] "Daylight illumination," 500 watt projection bulb with blue filter to give color temperature of 5,800° Kelvin.

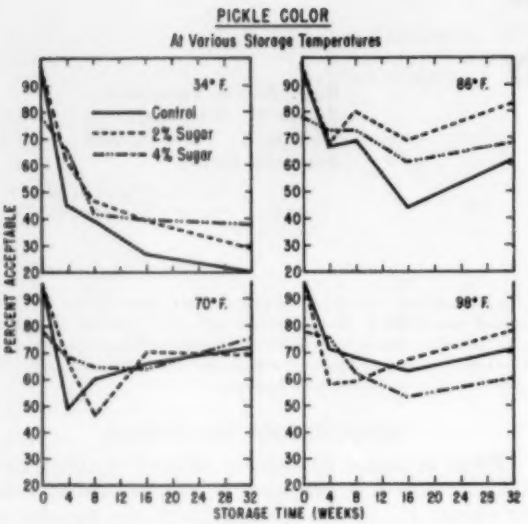

Figure 2.

press values were unaffected by the sugar variable except for an interaction between sugar and time. Acidity values, salt content, pH, and vacuum were unaffected by sugar content.

Effect of temperature of storage. In general, pickling flavor was unaffected by temperature of storage. However, slightly higher average scores were ascribed to pickles stored at 86° and 70° F. than to those stored at 34° or at 98° F. (Table 2; Figure 1). Samples stored at 70° F. showed the least decrease in flavor with time.

Texture desirability, whether measured objectively or subjectively, decreased with an increase in temperature (Table 2; Figure 3). At the lowest temperature (34° F.) the firmness of the pickles was observed to increase upon storage. Only minor texture changes were observed at 70° F. However, at 86° and 98° F. softening of the pickles occurred upon storage (Figure 3). These texture changes could be related to changes in the pectic substances which are accelerated at higher temperatures *(4)*. Analysis of variance of subjective texture measurements (Table 3) shows the extent to which temperature influenced texture changes.

Pickles stored at 70°, 86°, and 98° F. had a greater color acceptability than the pickles held at 34° F. The judges observed an undesirable blue-green cast of the pickles held at 34° F. This color development increased with time of storage at the lowest temperature (Figure 2). The smallest change in color from the onset to 32 weeks occurred in samples stored at 98° F. With the exception of small changes in the blue values, insignificant correlation coefficients were obtained between Colormaster values and subjective scores. However, there was a high

TABLE 1

Objective and subjective measurement of pickles at "0 time"

Quality factor	Sugar levels		
	0	2%	4%
Acidity			
Total	0.78%	0.75%	0.79%
Fixed [1]	0.41%	0.45%	0.53%
Volatile [2]	0.37%	0.30%	0.25%
Salt			
Brine	4.42%	4.41%	4.50%
Pickles	3.95%	4.12%	4.01%
pH			
Brine	3.54	3.58	3.58
Soluble solids			
Brine	6.29°	7.51°	10.77°
Vacuum	18"	18"	18"
Texture			
Shear press	467 lbs.	471 lbs.	466 lbs.
Subjective [3]	4.7	4.8	4.9
Color			
Objective [4]	0.8	2.8	1.7
Subjective [5]	96%	97%	78%
Flavor			
Desirable [3]	4.6	4.3	3.3
Undesirable [3]	1.7	1.9	2.8
Type undesirable Flavor	Too acid	Unbalanced Spicing	Too sweet
Over-all Reaction	4.1	4.0	2.7

[1] Calculated as % lactic acid.
[2] Calculated as % acetic acid.
[3] Average of 20 evaluations.
[4] Shades of color deviation from standard (ΔE).
[5] Percentage of judgments indicating "good" color.

TABLE 2

Distribution of cumulative values by sugar, temperature, and time[1]

Variable	Objective measurements [2]				Subjective measurements [3]				
	Acidity			Shear press	Flavor	Texture	Undesirable flavor	Over-all reaction	Color
	Fixed	Vol.	Total						
Sugar, %									
0	693	539	1229	6816	56.3	70.8	39.1	49.5	904
2	760	458	1214	6751	58.7	75.0	38.5	51.3	992
4	831	420	1245	6849	46.0	73.9	49.5	38.3	982
Temperature, ° F.									
34	569	354	919	5846	39.0	60.9	32.7	33.8	499
70	571	347	914	5643	41.7	58.1	30.7	35.4	775
86	578	350	926	4938	42.1	53.4	30.1	36.6	818
98	566	366	929	3989	38.2	47.3	33.6	33.3	786
Time, weeks									
4	559	363	919	6728	42.8	57.1	28.0	39.3	769
8	540	363	901	5520	41.5	56.4	30.2	35.2	712
16	582	362	939	4547	38.0	54.0	37.0	31.1	666
32	603	329	929	3621	38.7	52.2	31.9	33.5	731

[1] Values represent block totals used in the analysis of variance.
[2] Four replications per individual sample.
[3] Twenty replications per individual sample.

TABLE 3

Analysis of variance of subjective appraisal of pickles

Source	Degrees of freedom	Pickling flavor		Undesirable flavor		Texture		Color		Over-all reaction	
		Mean square	F ratio	Mean square	F ratio	Mean square	F ratio	Mean square	F ratio	Mean square	F ratio
Total	47										
Sugar	2	2.85	28.5[3]	2.39	29.88[3]	0.30	4.48[1]	145.09	3.30	3.10	51.67[3]
Temperature	3	0.31	3.1[1]	0.23	2.88	2.95	44.03[3]	1,828.47	41.57[3]	0.19	3.17[1]
Time	3	0.43	4.3[1]	1.22	15.25[3]	0.42	6.27[2]	152.81	3.47[1]	0.99	16.50[3]
S x Temperature	6	0.08	0.8	0.08	1.00	0.05	.....	95.72	1.28	0.06	1.00
S x Time	6	0.10	1.0	0.14	1.75	0.02	.....	57.14	1.30	0.13	2.17
Time x Temperature	9	0.34	3.4[1]	0.21	2.63[1]	0.62	9.25[3]	196.88	4.48[3]	0.25	4.17[3]
Error	18	0.10		0.08		0.067		43.99		0.06	

[1] Significant at P = 0.05.
[2] Significant at P = 0.01.
[3] Significant at P = 0.001.

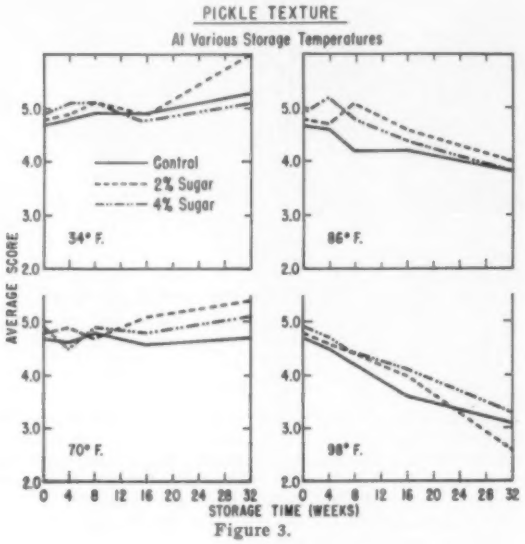

Figure 3.

negative correlation between shear-press texture values and subjective color evaluation (Table 4). This suggests that the visual color changes were not alterations of hue, which the Colormaster measures, but were a function of change in outer cell composition resulting in greater translucency and causing the pickles to appear a brighter and darker green. The color and texture data suggest that a cellular change is brought about by replacement of intercellular air spaces with liquid, causing the exterior of the pickle to appear less opaque. Analysis of variance showed the extent to which temperature affected color and indicated a time-temperature interaction (Table 3).

The over-all reaction values followed flavor scores closely and showed only slight variation as a result of temperature of storage (Tables 2, 3). Acidity, salt content, pH, and vacuum showed no variation with temperature of storage.

Effect of time of storage. Flavor quality decreased and off-flavor development increased with length of storage. In general, most of the flavor loss had occurred by the eighth week of storage with only minor subsequent losses (Figure 1). Although texture was more affected by temperature than by time of storage, there was a decrease from optimum with time (Figure 3). The best color was observed at the onset of the study and the poorest color scores were observed after the sixteenth week of storage (Figure 2).

Comparison between objective and subjective results. Table 4 summarizes the results obtained when correlation coefficients were determined for various comparisons. The only "r values" which were significant were obtained by comparing shear-press values with texture scores and with color scores. Vacuum of the capped jars varied only slightly and showed no correlation with color, flavor, or texture acceptability.

TABLE 4

Correlations between objective and subjective measurements

Factors compared	"r" value[1]
1. Shear press values vs. Texture scores	+0.71
2. Shear press values vs. Color acceptance	−0.70
3. Vacuum (inches) vs. Texture scores	−0.24
4. Total acidity vs. Flavor scores	−0.24
5. Volatile acidity vs. Flavor scores	+0.22
6. Fixed acidity vs. Flavor scores	−0.33
7. Colormaster Δ E values[2] vs. Color acceptance	+0.23
8. Colormaster green values vs. Color acceptance	−0.23
9. Colormaster red values vs. Color acceptance	−0.44
10. Colormaster blue values vs. Color acceptance	−0.65

[1] Correlation coefficient.
[2] Represents total color change.

SUMMARY

Genuine dill pickles varying in sugar content (0, 2, and 4% sucrose) were stored at 34, 70, 86, and 98° F., then evaluated after "0", 4, 8, 16, and 32 weeks. The sample containing 2% sugar was the most desirable in flavor, texture, color, and over-all acceptability. The data suggest that sugar served to protect the pickles against adverse color changes which occurred at the lower temperatures of storage.

The pickles softened considerably with increasing time and temperature of storage except when maintained at the two lowest temperatures. Refrigeration temperature (34° F.), however, caused an undesirable color development which had an inverse relationship to softening, suggesting that apparent color changes were alterations in cellular structure rather than changes in hue. Temperatures of 70° and 86° F. resulted in smaller quality changes than did temperatures of 34° and 98° F. The lowest quality was observed after 16 weeks of storage with little subsequent deterioration.

There were no significant effects of added sugar, time, or temperature of storage upon the total acidity, pH, salt content, or vacuum of the capped jars. Good positive correlation between shear-press values and texture scores was obtained.

Acknowledgments

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Interrelationships of Subjective, Chemical, and Sensory Evaluations of Beef Quality[a]

D. H. Kropf[b] and R. L. Graf
Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois

(Manuscript received July 8, 1958)

Federal beef grading is performed primarily to standardize beef and to give an estimate of the final eating qualities of the meat. In grading beef carcasses, quality factors are given primary emphasis; conformation and finish are secondary considerations. It may be that criteria other than those now emphasized in beef grading merit inclusion in judging the eating quality of beef. To test this hypothesis, a study was initiated to determine the interrelationships of various subjective, chemical, and sensory evaluations of beef quality. The objective was to provide information as to what factors are most closely related to the final eating qualities of beef.

EXPERIMENTAL

Materials. A total of 334 beef carcasses were used. These carcasses represented *choice*, *good* and *commercial* (also *standard*) grades steer, heifer and cow classes, and the following carcass weight groups: 400–500 pounds, 600–700 pounds and 800–900 pounds *(6)*.

Methods. Carcasses were selected to fit the middle of the grade in conformation, finish and quality factors by a representative of the U.S.D.A. Grading Service, who subjectively evaluated these carcasses with regard to fat covering, feathering, texture of lean, firmness of lean, color of lean, and bone ossification. Table 1 shows the scales by which these factors were evaluated.

Length of body, length of hind leg, and circumference of round were measured prior to cutting, as proposed in the *Proceedings* of the Fifth Annual Reciprocal Meats Conference *(7)*. Round index was calculated by dividing circumference of the round by length of hind leg. Chilled carcass weight was obtained immediately prior to cutting of the carcass. The carcasses were cut 24 to 48 hours after slaughter. Two adjacent loin strip-steaks were removed, wrapped, and freezer stored at −20° F. until randomly withdrawn for testing. One steak was used for determination of sensory acceptance, tenderness, flavor, and juiciness and the other for ether extract determinations and mechanical shear tests.

Sensory evaluations were conducted by the Food Acceptance Branch, Food Division, Quartermaster Food and Container Institute for the Armed Forces. The nine-point hedonic scale was used to evaluate over-all preference (Table 2). Structured scales were used to evaluate sensory tenderness, flavor, and juiciness (Table 2). Numerical values were assigned to each point on these scales.

Ether extract determinations and mechanical shear evaluations were made. For the latter purpose, steaks were removed from the freezer and allowed to temper at room temperature for 45 minutes or until soft enough to remove cores. Six one-half inch cores were removed from each tempered loin strip steak, the cores allowed to thaw completely, and then chilled at 40° F. for one hour. Core samples were cooked in a 158° F. water bath for exactly 3 minutes and then stored overnight at 40° F. in a closed container to preclude moisture loss. Shear values were obtained on a Warner-Bratzler shear machine.

Ether extract of the loin eye was determined by the A.O.A.C. procedure *(1)*.

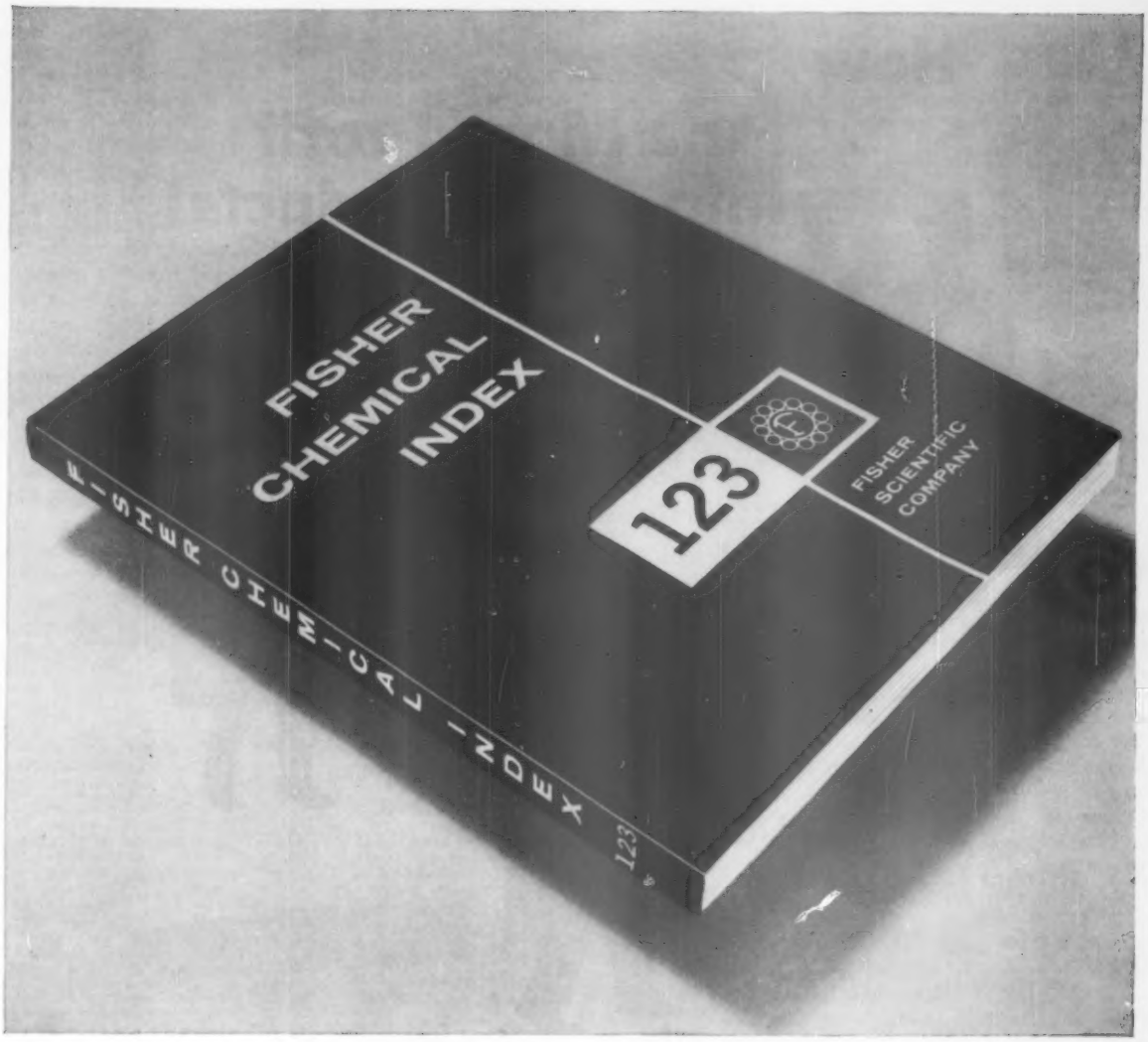
Average lot values for each of the 17 lots were determined and correlation coefficients were calculated from these average values.

RESULTS AND DISCUSSION

Length of carcass. Length of carcass was found to possess a highly significant strength of relationship

[a] This paper reports research undertaken by the Quartermaster Food and Container Institute for the Armed Forces, QM Research and Engineering Command, U. S. Army, and has been assigned number 853 in the series of papers approved for publication.

[b] Present address: Clemson Agricultural College, Clemson, South Carolina.



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with texture of lean ($r = -.77$), bone ossification ($r = -.76$), and carcass weight ($r = .84$), and significant correlation coefficients with color of lean ($r = -.49$), sensory preference ($r = -.55$) and ether extract of the loin eye ($r = .57$). The longer carcasses, naturally, tended to be heavier and had reached a more mature stage of bone ossification. Longer carcasses (indicative of greater maturity) were found to have a coarser textured lean in the rib eye. Since muscle cells during growth and fattening primarily increase in dimension, not in number, then any increase in muscle mass should be reflected by an increase in muscle diameter. This would logically result in a coarser textured lean. Bone ossification also showed the same highly significant relationship to texture of the lean. This was in agreement with results of Hiner *et al. (5)*, who studied muscles representative of each wholesale cut in vealers, cows, steers, and heifers and found a significant increase in fiber diameter with age in all muscles studied. The largest increase in fiber diameter occurred in cattle between 500 and 900 pounds live weight or 8 to 14 months of age. The relationship found between ether extract of the loin eye *vs.* length of carcass apparently was a result of

TABLE 1

Rating scales[1] for subjective factors

Marbling	Fat covering	Color of lean
Very Abundant	Very Thick	Dark Pink
Abundant	Thick	Very Light Cherry Red
Moderately Abundant	Moderately Thick	Light Cherry Red
Slightly Abundant	Slightly Thick	Cherry Red
Moderate	Slightly Thin	Moderately Dark Red
Modest	Thin	Dark Red
Small Amount	Very Thin	Very Dark Red
Slight Amount	Extremely Thin	
Traces	Devoid	
Practically Devoid		
None		
Texture of lean	**Firmness of lean**	**Bone ossification**
Very Fine	Very Firm	Soft and Pearly White
Fine	Firm	Slightly Ossified
Moderately Fine	Moderately Firm	Moderately Ossified
Slightly Fine	Slightly Soft	Nearly Completely Ossified
Coarse	Soft	Completely Ossified
Very Coarse	Very Soft	Hard and Flinty
Extremely Coarse	Extremely Soft	

[1] Most desirable characteristics were given highest numerical scores; each carcass was rated as *plus*, *average*, or *minus* within appropriate word description.

compensatory effect of Federal Grade Standards, i.e., a longer carcass probably needed more marbling to fit into a specified grade.

Round index. Round index (ratio of circumference to length of round) showed a highly significant strength of relationship to fat covering ($r = .89$), subjective marbling ($r = .87$), firmness of lean ($r = .90$), color of lean ($r = .66$) and mechanical shear value ($r = -.83$). It also exhibited significant correlation coefficients to sensory tenderness ($r = .53$) and ether extract of the loin eye ($r = .48$). Thus, it appears that this ratio of plumpness of round to length of round was closely and directly related to carcass finish and quality, and, through these factors, also related to tenderness as determined by both sensory and mechanical means.

TABLE 2

Rating scales for sensory evaluations of steaks

Numerical score	Sensory acceptance	Sensory flavor	Sensory juiciness	Sensory tenderness
1	Dislike Extremely	Extremely Poor	No Juiciness	Extremely Tough
2	Dislike Very Much	Very Poor	Slight Juiciness	Very Tough
3	Dislike Moderately	Poor	Moderate Juiciness	Moderately Tough
4	Dislike Slightly	Below Fair Above Poor	Much Juiciness	Slightly Tough
5	Neither Like Nor Dislike	Fair	Extreme Juiciness	Slightly Tender
6	Like Slightly	Below Good Above Fair		Moderately Tender
7	Like Moderately	Good		Very Tender
8	Like Very Much	Very Good		Extremely Tender
9	Like Extremely	Excellent		

Subjective fat covering. Subjective fat covering was found to possess highly significant correlation coefficients with subjective marbling score ($r = .84$), firmness of lean ($r = .87$), sensory tenderness ($r = .66$), mechanical shear value ($r = -.79$) and ether extract of the loin eye ($r = .61$) and significant strength of relationships to color of lean ($r = .48$) and sensory flavor ($r = .48$). Therefore, it was shown that external covering was closely related to quality factors such as marbling, lean firmness, color of lean and also to more final determinants of the eating qualities of beef mentioned above.

Subjective marbling. Subjective marbling score was closely related to many other factors evaluated in this study. It showed a relationship ($r = .74$) to ether extract of the loin eye. This compares favorably with a value of .65 reported by Cover *et al. (2)*, but both values appear somewhat low. Cover *et al.* stated that ether extract measures not only the fat seen as flecks of marbling but also that which occurs in deposits along seams of heavy connective tissues. This would not be called marbling. They also stated that ether extract values may be affected by deposits of fat too small to be seen as estimated marbling and by small amounts of ether-soluble substances which are not true fats. Marbling score also showed highly significant relationships to round index ($r = .87$), fat covering ($r = .84$), firmness of lean ($r = .90$), carcass weight ($r = .60$), sensory tenderness ($r = .62$) and mechanical shear value ($r = -.79$). A significant relationship of marbling to bone ossification ($r = -.49$) was found. This association of greater maturity with more extensive marbling may have been the result of the compensatory effect employed in the application of Federal Grade Standards.

Texture of lean. Texture of lean showed highly significant correlation coefficients with color of lean ($r = .84$) and bone ossification ($r = .64$) and a significant r of $-.54$ to mechanical shear value. Dark colored lean showed a tendency toward coarse texture. This was not surprising since both effects were

TABLE 3

Correlation coefficients of various subjective, chemical, and sensory evaluations

Length of carcass	Round index	Fat covering (subj.)	Marbling (subj.)	Texture of lean (subj.)	Firmness of lean (subj.)	Color of lean (subj.)	Bone ossification (subj.)	Carcass weight	Sensory preference	Sensory tenderness	Sensory flavor	Sensory juiciness	Mechanical sheer value	Ether-extract loin eye	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	vs.
	.05	.06 .89[2]	.34 .87[2] .84[2]	−.77[2] .36 .20 .03	.12 .90[2] .87[2] .90[2] .24	−.49[1] .66[2] .48[1] .42 .84[2] .56[1]	−.76[2] −.19 −.30 −.49[1] .64[2] −.43 .40	.84[2] .44 .35 .60[2] −.43 .37 −.08 −.80[1]	−.55[1] .07 .28 −.03 .41 .07 .21 .23 −.53[1]	−.07 .53[1] .66[2] .62[2] .29 .68[2] .35 −.32 .06 .53[1]	−.31 .40 .48[1] .26 .36 .23 .45 .31 −.04 .43 .23	−.03 .35 .24 .37 .29 .34 .25 .02 .20 .17 .53[1] .18	.18 −.83[2] −.79[2] −.79[2] −.54[1] −.85[2] −.74[2] .06 −.20 −.27 −.78[2] −.39 −.54[1]	.57[1] .48[1] .61[2] .74[2] −.28 .65[2] .06 −.64[2] .59[1] −.07 .54[1] .26 .24 −.47[1]	1 2 3 4 5 6 7 8 9 10 11 12 13 14

[1] Probability less than 5%.
[2] Probability less than 1%.

expected in more mature carcasses. Differences in lean texture of rib eye samples were found to have some effect on tenderness as measured by shear values. Similar results were achieved by Hiner *et al. (5)*, who reported a correlation coefficient of .75 between muscle fiber diameter and shear force value for neck samples and a correlation coefficient of .31 for foreshank samples. Correlation coefficients for other cuts of meat ranged between the values cited above.

Subjective firmness of the rib. Subjective firmness of the rib eye muscle was found to be highly correlated with sensory tenderness (r = .68), shear value (r = −.85) and ether extract of the loin eye (r = .65). Firmer lean tended to be more tender. Part of this effect may be explained by the fact that firmer lean tended to possess more marbling as shown by the high correlation coefficient with ether extract of the loin eye. It was also closely related to subjective fat covering score (r = .87) and subjective marbling score (r = .90). Therefore, firmness of lean may be important partly because of its close relationship to finish and marbling. However, firmness of lean muscle may be affected by ionic balance between inter- and intra-cell ions which would affect the water-holding capacity of the muscle or juiciness of the final product. Wierbicki *et al. (10)* implicated ionic relationships and their role with regard to tenderness of lean muscle. Therefore, the fact that firmness of muscle was clearly related to tenderness seemed feasible. This factor may be difficult to evaluate objectively, but an accurate evaluation of firmness of lean may be of considerable value in estimating tenderness of the final cooked product. Firmness of lean also showed a significant relation (r = .56) with color of lean. Perhaps the chemical state of meat pigments may be related to tenderness or firmness of muscle as well as to redness or darkness of color. Lean firmness may hold considerable promise as an indication of tenderness. This relationship should be further exploited.

Color of lean. Color of lean was found to have a highly significant strength of relationship with mechanical shear value (r = −.74). This may have been primarily due to the close association of color with other factors related to tenderness. Wierbicki *(8)* had previously reported that color had essentially no relation to tenderness.

Sensory tenderness. Of all the factors tested, only length of carcass (r = −.55), carcass weight, (r = −.53) and sensory tenderness (r = .53) were significantly related to over-all preference. Loin strip steak from shorter, lighter carcasses were preferred. It was interesting to note that while tenderness had a significant correlation coefficient of .53 to preference, flavor and juiciness had non-significant correlation coefficients of .43 and .17 respectively, to preference. Thus it appears that tenderness may have been the most important single sensory determinant of acceptability. Hankins *(4)* had previously expressed the opinion that no meat attribute is a greater liability than toughness. Flavor tended to show a positive relationship to preference, but juiciness showed a poor strength of relationship to preference in this study. However, juiciness appeared to contribute to tenderness as shown by significant correlation coefficients both to sensory tenderness (r = .53) and to mechanical shear value (r = −.54). Greater juiciness was associated with greater tenderness. Griswold *(3)* achieved a correlation coefficient of .81 between flavor of lean and acceptability. However, since she used the cuts from only two *prime* and four *commercial* beef carcasses, her study did not represent the range of grades, classes, and weights as well as does the present study. She failed to report what relationship, if any, existed between tenderness and preference.

Sensory tenderness *vs.* mechanical shear value showed a highly significant correlation coefficient of −.78. The negative value is explained by the fact that in scoring sensory tenderness, highest values indicated greatest tenderness. Carcasses with thicker fat covering and firmer lean tended to produce more tender cuts. Since these factors were closely associated with grade, it seemed that grade was related to tenderness.

Sensory tenderness also was related to round index (r = .53) (apparently since round index was closely related to finish), fat covering (r = .66), firmness of lean (r = .68) and percentage ether extract in the loin eye (r = .54). Mechanical shear value showed similar but stronger relationships to these factors, in

addition was also correlated with marbling score ($r = -.79$), texture of lean ($r = -.54$) and color of lean ($r = -.74$). The shear values were more sensitive determinants of meat tenderness than the sensory values for which an 8-point structured scale was used. Therefore shear values showed stronger relationships to other factors than did sensory tenderness. Wierbicki *et al. (8)* had previously reported that both carcass grade and intramuscular fat of the *Longissimus dorsi* were related to tenderness at 3 days post mortem. This relationship became weaker after aging up to 15 days.

SUMMARY

Three hundred and thirty-four beef carcasses representing a wide range of grades, classes, and carcass weights were used to determine interrelationships of various subjective, chemical and sensory determinations.

As the beef animal matured, a pronounced tendency existed for carcass lean muscle to become more coarse textured and darker colored.

A greater round index (ratio of circumference to length of round) was found to be closely related to a higher degree of finish (fat covering or marbling) and, through these factors, also related to tenderness.

Fat covering was closely related to marbling, lean firmness, color of lean, tenderness, flavor and ether extract of the loin eye.

Sensory preference had a correlation coefficient of .53 (significant at 5% level) to tenderness and correlation coefficients of .43 and .17 (non-significant at 5% level) to sensory flavor and juiciness, respectively. Preference was significantly related to carcass length and weight.

Tenderness of lean increased as external and internal finish increased and as lean became firmer. Juiciness had a significant correlation coefficient of .53 to sensory tenderness. Mechanical shear values were highly related to sensory tenderness and appeared to be more sensitive as a measure of tenderness.

Subjective marbling score *vs.* ether extract of the loin eye showed a significant correlation coefficient of .74.

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Pectin Standardization

Final Report of the IFT Committee[a]

THE ANNUAL PRODUCTION of pectin is now well above six million pounds in the United States and substantial quantities are produced abroad. This industry serves mainly the needs of the jam and jelly manufacturers who in the United States alone produce over 600 million pounds of fruit spreads of various sorts annually. A major portion of the domestic pectin production goes into foods where the usefulness of the pectin depends on its gel forming ability such as in jams, jellies, preserves, marmalades, confectionery, and bakery items and the like. Although there have been recognized standards of performance on which the buyer and seller of pectin can agree, no widely accepted methods for preparing or evaluating test jellies from a pectin sample have ever been established.

HISTORICAL BACKGROUND

In 1947 the National Preservers Association recognized the need for such a standard and through a survey of its preserve industry members found that pectins offered for sale on the basis of identical jelly grade[b] at times differed as much as 30% in effectiveness in actual usage. The Association thereupon assigned to a committee the task of proposing a method by which the grade of pectin suitable for the manufacture of jellies containing 65% soluble solids could be assessed, the intention being to agree on a generally acceptable procedure.

A subsequent survey showed that members of the Association used several methods of test jelly preparation and a variety of equipment for the evaluation of test jellies. Of the instruments of measurements, the Tarr-Baker Delaware Jelly Tester *(1)* and the Exchange Ridgelimeter *(8)*, shown in Figure 1, were thought to be giving the most reproducible results. Several manufacturers used other devices for measuring jelly firmness and determining grade. These included the Bloom Gelometer *(4)*, various viscometers, weight-and-plunger devices, etc. and "experienced fingers." Preservers indicated in this survey that breaking strength was the most important attribute to characterize pectin jelly quality since they believed it to be most closely reflecting spreadability and shipping quality.

Enter the IFT. At the Annual Meeting of the IFT, held in Philadelphia, Pa., in June, 1948, a group of people interested in pectin discussed the status of various methods and procedures used by manufacturers of pectin for establishing its grade. It became clear from this discussion that no two manufacturers used the same method of preparing test jellies or evaluating them. Many people felt that an article of commerce as important to the food industry as pectin should have a well-defined grade and that a reproducible and generally acceptable method for preparing and evaluating test jellies would be desirable. Others felt that the integrity of pectin manufacturers assured the customer of a reliably uniform supply. It was suggested at this meeting that the President of IFT appoint a committee and charge it with the task of recommending a pectin jelly grade evaluation procedure which has a reasonable chance of acceptance by both manufacturers and users of pectin. Such a committee, in fact, continuing the effort initiated by the National Preservers Association and designated as the IFT "Committee on Pectin Standardization" was appointed late in 1948. It included representatives of 6 pectin manufacturers, 3 additional pectin manufacturers who were users as well, 4 users of pectin, and 3 people from academic and governmental institutions with research experience in this field.

Under the chairmanship of Dr. J. J. Willaman, the task of the Committee was defined as "establishing a

Figure 1. The Exchange Ridgelimeter, used for determining the firmness of pectin test-jellies. The specially calibrated "Ridgelimeter Glasses" are shown, with and without the tape "sideboards."

[a] The following persons participated in the Committee's work:

George L. Baker[1]	Z. I. Kertesz[2, 5]	William A. Rooker
E. R. Barron[2, 5]	Louis Lataillade	Weldon Scardino[2, 5]
Page R. Boyles	H. T. Lee[2, 5]	Howard Shockey[2, 5]
J. J. R. Bristow[2, 5]	W. D. Maclay	W. Lowe Walde
R. E. Buck[2, 5]	E. Everett Meschter[4, 5]	Robert Webb[2, 5]
H. A. Campbell	H. H. Mottern	J. J. Willaman[3]
P. Gilbert	Jack Nelson[2, 5]	Powell Williams[1]
L. K. Harper	Miss Mamie Olliver[2, 5]	C. W. Woodmansee[2]
G. H. Joseph[2, 5]	H. S. Owens[1]	
C. W. Kaufman	Robert Reeves[2]	

[1] Deceased. [2] Committee members, 1958–59. [3] Chairman, 1948–53. [4] Chairman, 1953–59. [5] Committee members, 1948–59.

[b] "Jelly grade is the proportion of sugar which one part of solid pectin or pectin extract is capable of turning, under prescribed conditions, into a jelly of suitable characteristics" *(11)*. Assigning definite meanings to the terms "prescribed conditions" and "suitable characteristics" is, in essence, the subject of this report.

standard method for grading pectin to be the basis and reference in the selling and buying of pectin for use in 65% soluble solids sugar jellies." It was thought that there should be a single procedure to be used on pectin from citrus or apple, sold dry or in solution, rapid or slow set, jelly or jam type, and that this method should become eventually mandatory in the evaluation of pectin in commerce. Obviously, the manufacturer or preserver still could use any other test he wished in process control and all these methods could be correlated to a uniform single accepted standard procedure.

BRIEF SUMMARY OF THE COMMITTEE'S WORK

It was the opinion of the Committee that the use of such a standard procedure would be commercially feasible and that manufacturers would eventually agree to abide by such evaluation of their product in commercial competition. Members of the Committee were then questioned concerning their opinion as to which of 6 recently proposed methods [c] of pectin evaluation they consider most suitable to serve as a starting point in a collaborative study. The methods were: (a), the Tarr-Baker Jelly Tester measuring breaking strength *(1)* as described by Baker and Woodmansee *(2)*; (b), the Bender *(3)* and (c), the Mottern and Karr *(13)* modifications of the Delaware Tester; (d), the Meschter and Lataillade *(12)* procedure of using jelly discs with a modification of the Delaware Tester; (e), the Owens, Porter, and Maclay modification *(16)* of the B.A.R. method *(5)* measuring the elastic modulus by the torque produced by turning a blade immersed in the jelly; and (f), the Exchange Ridgelimeter measuring jelly sag as described by Cox and Higby *(8)* and Joseph and Baier *(10)*. The various attributes of these methods were listed under several categories such as whether the acid was to be added to the mixture which was boiled or to the glasses, the pH levels to be studied, the storage temperature for the jelly before firmness measurement, whether water, a salt solution, or fruit juice was to be used in the preparation of the jelly, the number of glasses of test jellies prepared, etc. Each of the methods was rated by Committee members as to which one showed most promise as a starting point for testing. The tallying of the answers revealed a slight preference for the general procedure described by Joseph and Baier *(10)* both for the preparation of the test jelly and the testing the sag of the finished jelly. The majority of committee members also agreed to the eventual adoption of a method which was not their own as long as it satisfied the above stated requirements.

The complexity of the problem became apparent at this point. Some Committee members felt that it was not possible to select a method of jelly strength measurement until the jelly characteristic on which the evaluation is based is more clearly defined. The methods before the Committee included measurements of top strength, bottom strength, slice strength by the Delaware Tester and its modifications, and rigidity measurements by the sag and torque methods and thus provided a wide choice of evaluation schemes. The problem of pH was more complex than simply defining the pH levels to be used in test jellies since one would have to decide whether the testing should be done at the optimum pH for the pectin which may or may not lie in the pH range of actual usage. If the test is made in the pH range of actual usage, one must decide if the pH of testing rapid-set and slow-set pectins should be identical or different.

The Exchange Ridgelimeter was selected as the first test instrument to be used because it is rugged, compact, reliable, inexpensive, easy to use, and gives reproducible results. Some members accepted this choice with reservation since this instrument was not designed to measure some jelly characteristics sought by preservers. On the other hand, there was agreement that this instrument, used in conjunction with a reproducible method of test jelly preparation, would give a reliable index of the sugar holding capacity of a pectin. However, results obtained by its use would not enlighten preservers as to the spreadability characteristics and might have limited application with products in the higher pH range. In spite of these recognized limitations, the Ridgelimeter was selected as test instrument since no other method of evaluation met with any comparable degree of acceptance. The Committee thereafter concentrated its work on the "acid in glass" method and on the use of the Ridgelimeter for test jelly evaluation.

It has been previously brought out by the National Preservers Association survey that preservers were interested not only in attaining uniformity in pectin grading but also in obtaining information about the characteristics of the pectin in use under various conditions of pH and type of jelly. If the latter were to be included in the Committee's work, the problem would expand greatly beyond pectin grade assessment. It was also realized that many important characteristics of fruit jams and jellies such as spreadability, flavor, firmness, shipability, etc., can be altered at will and without involving the inherent jelly forming ability of the pectin used and that the assignment of this Committee was to study pectin standardization rather than the various properties of jellies and jams, important as these may be.

In retrospect it is clear that the Committee's first major experimental program was entirely too broad to yield significant results. It included the testing of one apple and 3 citrus pectins (all of 150 grade) at 3 pH levels (2.6, 3.1, and 3.5) and using water, Olsen's buffer solution *(15)*, depectinized currant juice and depectinized apple juice as media. The jellies were to be tested by each operator after standing for 1, 7, and 30 days at room temperature. The results indicated that none of the tests gave readings of 150 grade after one day's standing and that no constant grade was obtained even after 30 days. In many tests no jelly was obtained at all, particularly with slow set pectin. The variations in the results obtained by different operators were large. On one of the pectin samples, for instance, the grade obtained ranged from 120 to 150.

Sharper definition of procedure sought. Thus, it became apparent that the conditions of test jelly preparation and testing must be much more exactly defined. Clearly, the pH was a critical item and it was considered unwise to test pectins at jelly pH values above 3.0 since above this value the results became more erratic. The strength of the jellies increased upon standing, the jellies having pH values above 3.0 showing more gain than those being below pH 3.0. These results seemed to give credence to the theory that test results of the "acid in glass" procedure at pH below 3.0 would give more reliable results in one day than at higher pH values. The majority of Committee members felt that comparable uniformity could not be obtained in the "use" range of pH 3.0 to 3.4. The opinion has been also expressed that the Ridgelimeter evaluated apple pectins unfairly because of the apparent greater elasticity of the jellies. Such pectins might produce higher Delaware Jelly Tester breaking strength values per unit of sag than jellies produced with some citrus pectins. Evidence to support this theory was brought to the attention of the Committee by the appearance of Christensen's article *(6)*. This point was not resolved and the Committee's work continued with full recognition that such factors might cause disagreement. Results of Ridgelimeter measurements on jellies of pH 2.4 could in some measure be evaluated for use value. Since preservers do not usually expect pectins to operate identically with fruit juices of various pH values, the optimum pH value and satisfactory operating range of the pectin would have to be determined by other means anyway. Therefore, the Committee decided to work toward the refinement of a method to obtain a reproducible, "acid in glass," Ridgelimeter-evaluated jelly. It was agreed that, for the present, no reference would be made to "grade" since this factor could not be established until a reproducible method would allow its assignment.

In 1953, Meschter succeeded Willaman as the Committee's Chairman. At the IFT Annual Meeting in Boston in that year, the Committee decided to ask Joseph of the Research Department of Sunkist Growers to write up a set of precise instruc-

[c] For a survey of test jelly evaluation methods see Meschter and Lataillade *(12)* and pages 480–503 in ref. *(11)*.

tions for jelly preparation and testing. This method (6–53) was tested by all Committee members in their respective laboratories. The results were encouraging and a second pectin sample was then tested. After all observations were summarized and evaluated, Joseph was requested to rewrite method 6–53, incorporating the various suggested refinements. This method, designated as 5–54 (May, 1954, see Appendix) was tested by the Committee members on several samples, including citrus and apple pectin.

On the basis of the results obtained, the Committee believed that the reproducibility obtained was the practical ultimate of the Committee's pectin testing effort. The agreement between tests conducted in 15 laboratories was excellent. On the last two pectin samples (one citrus and one apple pectin) tested, the average sag values were 24.72% and 23.35%. The ranges of measurements were only 24.0%–25.7% in one case and 22.7%–24.6% in the other. The calculated standard deviation was 0.513 for the first set of data and 0.447 for the second. The standard error of the mean was only 0.185 for the citrus pectin and 0.172 for the apple pectin. This precision is considered entirely adequate for commercial application.

In a discussion of these results, the Committee agreed to discontinue further testing since it was believed that the necessary precision in the method has been attained and it was deemed unnecessary to improve on the method of test jelly preparation and evaluation. It was also agreed that further work of the Committee is not likely to resolve the controversial points in jelly grade evaluation and that it was unlikely that sufficient continued interest could be maintained to arrive at a similar refinement in the evaluation of jelly breaking strength measurements. Therefore the Committee agreed that its activity should be terminated and requested Chairman Meschter to prepare a report on the Committee's work and accomplishments.

DISCUSSION

Method 5–54 (see Appendix) developed by the Committee is a reliable and reproducible procedure of considerable exactness for evaluating one characteristic of pectins, namely, the sugar holding capacity as measured by the sag of the test jelly. It fails to give information on the optimum or the operative range of pH. It fails to describe the surface strength of the jelly or to evaluate the usefulness of the pectin in certain kinds of jellies at various pH values. Thus it does not give information on several points of interest to preservers. As the result of its experimental work and deliberations, the Committee recognizes the great difficulties of finding any simple test procedure which will indicate the usefulness of the pectin under more than a few of the countless conditions which pectins meet in actual commercial use. Some preservers add pectin to the batches of jelly in the dry form, others add it in solution. Some use vacuum pans for cooking at low temperatures, others use high temperatures in open steam or in direct-fired kettles. Some use naturally hard water, others soft. Some attain firm sets in their product, others favor a more delicate set. Some add acid in the batch, others add acid in the glass. The rate of product cooling varies in different plants. Even in the same variety of preserve, tartness and sweetness are not uniform from plant to plant. Thus it seems impossible, at this time, to give a simple, exact definition of "use conditions."

Nevertheless, the Committee feels that method 5–54, while not necessarily the best, is a procedure which 15 operators found easy to reproduce with sufficient exactness on 5 different types of pectin samples and is regarded as a reliable measure of the sugar holding capacity of any pectin suitable for the manufacture of fruit jellies containing 65% soluble solids.

Since the conclusion of the Committee's laboratory work, Olliver and coworkers *(14)* in England published a test method for use in that country. It specifies a final soluble solids concentration of 70.5% ± 0.5% and a pH of 3.10 ± 0.05, conditions which pertain particularly in the English preserving industry. The Ridgelimeter, used in method 5–54, is specified as the test instrument by the British Committee on pectin standardization. This principle of sag measurement has been also accepted in the Netherlands *(9)*. Denmark has no officially accepted method but Københavns Pektinfabrik *(7)* applies solely firmness grade sag method for their domestic and export sale.

SUMMARY AND RECOMMENDATIONS

The purpose of this final report is to summarize the activities of the Committee over a ten-year period, pointing out its accomplishments and failures. It is hoped that this report will serve as a stepping stone for some future group continuing this work.

Procedures for making and evaluating test jellies have been developed and tested. In the Committee's view, Method 5–54 (see Appendix) is suitable for the objective and exact determination of the jelly grade (sugar holding capacity) of pectins sold for the manufacture of 65% soluble solids jellies.

It is recommended that this method, designated as "Method 5–54 of the IFT Committee on Pectin Standardization," be recognized as a proposed standard procedure for the grade evaluation of pectins sold for the manufacture of 65% soluble solids jellies. Information obtained by this method will be helpful in the evaluation of a variety of different pectin products. The Committee recognizes the fact that pectin evaluation by Method 5–54 does not give all the information sought by preservers using pectins in different products of widely varying properties and requirements.

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APPENDIX

METHOD 5-54 OF THE IFT COMMITTEE ON PECTIN STANDARDIZATION

This procedure is based on the method described by Cox and Higby, in *Food Inds.*, **16**, 441 (1944) and Joseph and Baier, *Food Technol.*, **3**, 18 (1949). The instructions given below are complete for the preparation of the test jellies and for the measurement of test jelly sag.

A. Preparation of Jelly

Calculate the weight of Pectin to use by dividing 650.0 by the value of an assumed firmness grade (a) for the Pectin.

(a) Jellies produced by this Method should contain 650.0 g. of total soluble solids in 1000.0 g. of jelly. The ratio of the actual weight of *total soluble solids* in a *particular* jelly to the weight of Pectin in *that* jelly is defined as the "assumed grade" for the Pectin, in that specific jelly. Hence, the weight of Pectin to use in a jelly is given by the expression: 650/assumed grade.

Weigh into a dry container the amount of sugar needed which will be 650.0 minus the weight (to the nearest gram) of Pectin used. (b)

(b) Examples: Suppose one assumed a "firmness grade" of 150, then 650/150 or 4.33 g. would be the weight of Pectin to use and 650–4 or 646 would be the grams of sugar to use. The sugar should be the finely granulated type made for table use, where about 75% is within the band of 35–80 mesh.

Transfer about 20–30 g. of the weighed sugar into a dry 150 ml. beaker and add the weighed Pectin sample. Mix the Pectin and sugar thoroughly in the small beaker by stirring with a spatula or glass rod.

Put 410 ml. of distilled water into a 3-quart stainless steel sauce pan (c) containing a stainless steel potato masher (d) for stirring. (The sauce pan and stirrer should have been tared previously, on a scale or balance).

(c) EKCOWARE 3-qt. stainless steel pan No. 7323, FLINTWARE 3-qt. pan No. 7623 or REVERE 3-qt. copper-clad pan No. 1403 are excellent examples of pans suitable for this purpose.

(d) A FLINT stainless steel potato masher No. 1905 made by EKCO Products Company, Chicago 39, is ideal for stirring and skimming Pectin test jelly batches.

The pectin-sugar mixture is now poured into the water all at once (e) then gentle stirring is started and continued for about 2 minutes.

(e) The object here is to get the sugar-pectin mixture *under* the surface of the water as quickly as possible. When hot water is used the sugar dissolves too quickly and the pectin tends to stay on the surface and stick to the sides of the pan. Avoid splashing when stirring so pectin is not scattered to upper parts of pan. Just before the pan is put on the heater or stove any traces of pectin-sugar remaining in the small beaker should be transferred to the jelly batch.

The jelly kettle or sauce pan is then placed on a stove and heated until the contents come to a full rolling boil, stirring being continued during this period. The remaining sugar is added and heating and stirring continued until the sugar is dissolved. Heating is continued until the net weight of the jelly batch is 1015.0 g. (f).

(f) The gas or electric stove should be adjusted *so that the entire heating time for the jelly is 5–8 minutes!* When an electric stove is used it should be preheated. The stirrer is to be left in the kettle during the cooking and weighing period. If the batch weighs less than 1015 g., distilled water is added in slight excess so that additional boiling will be necessary to reduce the net weight to 1015 g. The amount of water used at the start should be adjusted by each operator so that the entire heating time is kept within the 5–8 minute range.

After the 1015-g. batch is removed from the balance or scale, it is allowed to sit undisturbed on the desk-top for one minute, then the pan is tipped so that the contents are nearly ready to overflow, and any foam or scum is quickly skimmed off. The stirrer is removed and a thermometer is put into the jelly batch. While the kettle is tipped the batch is stirred gently with the thermometer until the temperature reaches exacly 95° C. The batch is then *poured quickly* into three previously prepared Ridgelimeter glasses, each containing 2.0 ml. of tartaric acid solution. (g)

(g) *Acid Solution:* The acid solution should be made by dissolving 48.80 g. of tartaric acid crystals in distilled water and making up to a total volume of 100.0 in a volumetric flask.

Preparation of Glasses: The Ridgelimeter glasses are Hazel-Atlas No. 85 tumblers which have been ground down so that the inside height is exactly 3.125 inches. Scotch drafting tape or Mystik masking tape, ¾ inch wide and 9½ inches long is used to make sideboards on each glass. The strip should cover the top ¼ inch of the glass and must extend ½ inch *above* the glass. Squeezing the tape against the glass, especially under the flange near the top of the glass, will insure a tight seal which will not leak hot jelly.

Cooling to 95° C.: Pectins whose jellies set at different rates are difficult to grade precisely unless their jellies are poured at some very definite and constant temperature. This fact was recognized by Stuewer, Beach and Olsen in 1934 (*Ind. Eng. Chem., Anal. Ed.*, **6**, 1943) when they said, "Observations made here indicate that most of the difficulties involved in the routine evaluation of apple pectin jellies may be obviated by the simple expedient of preparing the jelly mixture without acid, adding an excess of acid to the glasses, and pouring the jelly mixture into these at exactly 96° C."

It is known that the acid concentration (by titration and by pH) as well as the soluble solids can differ from top to bottom in a glass of jelly, even when the acid is added to the batch before it is poured. The differences in acidity are too small to be significant when the pH is below about 3.0.

Pouring the Jelly: A glass rod should be in only one of the jelly glasses. When the jelly batch has cooled to 95° C. it is poured in the first glass as rapidly as is consistent with reasonably accurate filling, the jelly being stirred vigorously with the glass rod *only* during filling, *but no longer*. The glass rod is put into the second glass, pouring is done as before, and so on for the three glasses. It is best to pour very rapidly until the glass is filled part way up the sideboards, then to pour more slowly so that the glass can be filled completely full to the point of overflowing. There is ample evidence to show that the 2.0 ml. of acid gets suitably mixed in the glass of jelly when rapid pouring is done as mentioned above.

About 15 minutes after the glasses are filled they are covered with their regular metal lids which can be fitted snugly over the "sideboards." The jellies should be stored 20–24 hours, at 25° C. ±3.0° C. (h)

(h) If room temperature is outside the range of 22–28° C., allow the jellies to cool to about 30°–35° C. then put them into an incubator at 25° ± 3° C. for 20–24 hours.

B. Measurements on the Test Jelly

1. Determination of the Jelly Sag

After the jellies have been stored for 20–24 hours, the lids are removed from the glasses and the tape strips torn off. A tightly stretched wire, clean and wetted (cheese cutter furnished with the Ridgelimeter) is carefully drawn across the top of the glass while the latter is held upright and is turned slowly part way around, so that a smooth cut is made to remove the layer of jelly projecting above the top of the glass. The detached top layer is carefully removed and discarded.

The jelly is turned out of the glass into an inverted position on a plate glass square furnished with the Ridgelimeter. This is accomplished by holding the glass tilted at about a 45° angle while the point of a spatula is inserted between the top of the jelly and the glass, to start the separation of the jelly from the glass. The jelly should pull away from the glass while the latter is rotated slowly, *without* further aid from a spatula. The glass is quickly and carefully inverted just above the glass square in such a way that the jelly slides out and stands upright near the center of the glass plate. Do not drop the jelly onto the plate!

A stopwatch is started as soon as the jelly is on the glass plate. If the jelly leans slightly to one side, this usually can be corrected by gently tilting the glass plate away from the direction in which the jelly leans. The plate and jelly should now be placed carefully on the base of the Ridgelimeter so that the jelly is centered under the micrometer screw, which then should be screwed down *near* to the surface of the jelly. (The Ridgelimeter should be used only on a *level* desk or table.)

Two minutes after the stopwatch was started, the point of the micrometer screw is brought just into contact with the top jelly surface. Illumination should be arranged so that contact of the micrometer tip with the jelly surface can be observed easily. The lowest line on the vertical scale beyond which the lower edge of the circular micrometer head has passed, is the per cent and the number on the micrometer head nearest the vertical scale denotes the tenth of a per cent sag. The Ridgelimeter reading is recorded only to the nearest 0.1 (j)

(j) Check of Ridgelimeter Calibration: A ⅝ inch brass rod exactly 2.500 inches in length may be used to check the Ridgelimeter scale and *must* be used to adapt the instrument for using new glass plates. A slight shift in the vernier and/or in the scale, or use of a glass plate other than the one originally sent out with the instrument, can result in unreliable readings. It is easy to check the instrument by standing the 2.500 inch gauge rod upright on the glass square, under the tip of the micrometer screw. When the tip of the screw is in *gentle* contact with the gauge rod, the instrument should read exactly 20.0. Both the vertical scale and the vernier knob can be reset so the instrument *does* read exactly 20.0 when checked with the 2.500 inch rod as just described. Occasional checking by this method is recommended to insure that the scale settings remain fixed.

When Ridgelimeter readings on different glasses from the same jelly batch differ more than 0.6, the batch should be remade.

2. Determination of Soluble Solids and pH of Jelly

After the second glass poured has been tested on the Ridgelimeter, cut it into halves lengthwise and remove a small portion from the center of the jelly and spread it quickly over one of the refractometer prisms. Quickly close the refractometer, firmly, and after about a minute or so, read the instrument, recording also the temperature of the prisms (the water circulating through the instrument) so that later corrections can be made for getting the soluble solids at 20° C. by the table of corrections in the appendix of *Methods of Analysis*, (k) 8th Edition, page 886, Assoc. Offic. Agr. Chemists, Wash., D. C. 1955.

(k) When the soluble solids content of these test jellies is as much as 1.0 unit from 65.0% at 20° C., serious errors must have entered into the method of making the jellies. A spread of ± 1.0% soluble solids can mean an error of ± 3 to 4% in jelly grade, a larger error than is involved with ordinary use of the Ridgelimeter. It is necessary, therefore, to get correct soluble solids readings by being careful that samples for testing are always taken quickly from an unexposed jelly surface, and that temperature is given due consideration.

Mention was made in Note (g) that the acidity and soluble solids may vary from top to bottom of a glass of jelly, regardless of whether or not acid was in the batch or in the glass. These variations are too small to be of consequence when the pH is considerably below 3.0, as in the present method, and they vary in magnitude and even in direction, from one pectin type to another.

The pH can be determined by taking a portion of jelly from the center of the second glass and crushing it into a small beaker where a glass electrode system may be inserted into the jelly mass. If the pH equipment is in suitable condition a value accurate to a few hundredths of a pH will be attained in a few moments.

C. Calculation of Jelly Grade of the Pectin

Although Method 5–54 was developed by the Committee specifically for cooperative testing of the reproducibility of the test jelly preparation and sag measurement, it might be desirable to describe briefly the calculation of the Pectin jelly grade from the sag measured.

The Cox-Higby method assumes a jelly sag of 23.5% as "standard firmness." From the sag measurements as described above, the true grade of the test Pectin (as contrasted with the "assumed grade" discussed in points a and b) may be ascertained by the use of a curve given by Cox and Higby in their publication. The relationship between "assumed grade" and the factor to obtain "true grade" is represented by a very slightly S-shaped curve. In the absence of this curve, the nearly linear relationship allows an approximation by dividing the per cent sag as read on the Ridgelimeter by 23.5, and subtracting this value from 2.0. When multiplying the "assumed grade" of the test Pectin by this latter factor, the approximate "true grade" is obtained. However, the curve in the Cox-Higby article (quoted above) will give more exact results.

Some Factors Influencing Radiation Induced Chemical Changes in Raw Beef[a,b,c]

O. F. Batzer, R. A. Sliwinski, Lucy Chang, Katherine Pih, J. B. Fox, Jr., and D. M. Doty
American Meat Institute Foundation, Chicago, Illinois

and

A. M. Pearson and Mildred E. Spooner
Department of Animal Husbandry, Food Technology Program, Michigan Agricultural Experiment Station, East Lansing, Michigan

(Manuscript received March 12, 1959)

INVESTIGATIONS into the possible application of beta or gamma radiation for the sterilization of fresh meat and meat products have indicated that, although a sterile product can be obtained, the radiation dosage required for sterilization causes a number of undesirable changes which include off-odors and off-flavors.

Previous research at our laboratory led to isolation and identification of some of the compounds responsible for off-odors *(1)*. Methods were developed and existing methods adapted to estimate some of the chemical changes that occurred when fresh beef was irradiated. Among these changes were increases in hydrogen sulfide, methyl mercaptan, acid-soluble carbonyl compounds, and pH. The disappearance of glutathione and glycogen was also followed. Results from earlier experiments suggested that sample differences, such as age, grade, and storage temperature affected the degree of chemical change occurring during radiation.

Studies were made to ascertain the influence of pre- and post-irradiation storage time and temperature, variations of radiation dosage, and grade of beef. After completion of the first study, the experiment was replicated.

EXPERIMENTAL PROCEDURES

Paired beef ribs and short loins were obtained from a local meat packing plant immediately after chilling. U. S. Grades, *prime, good,* and *utility* were chosen to obtain different fat levels. Moisture, fat, and protein contents are listed in Table 1. Sections of rib and loin of each grade were aged for 3 weeks at 0, 35, and 45° F. prior to sample preparation and irradiation. Only the *Longissimus dorsi* muscle was used. After being stripped of all extraneous fat, it was passed 3 times through a food chopper fitted with a fine plate. Individual samples were weighed and placed in glass vials. After irradiation, certain designated samples were stored for 3 months at 35, 60, and 90° F. In order to minimize the number of samples to be analyzed, the experimental design was based on an incomplete square for future analysis of variance.

Samples were irradiated in the gamma source at Argonne National Laboratory, Lemont, Illinois.

Analyses for hydrogen sulfide followed the procedure as described by Marbach and Doty *(2)*, and methyl mercaptan according to Sliwinski and Doty *(3)*. Acid-soluble carbonyls were estimated by a modification of the procedure of Lappin and Clark *(4)* as described by Batzer *et al. (5)*. Glutathione was determined by the method of Grunert and Phillips *(6)* after electrolytic reduction according to Dohan and Woodward *(7)*. Glycogen estimations were made using the procedure of Carroll *et al. (8)*. pH measurements were made on a slurry of meat and distilled water.

The amount and kind of heme pigments present in the samples were analyzed by making an extract with a weight of water equal to the weight of the sample, allowing the slurry to stand in the cold for 2 hours and then centrifuging. All colored components were extracted by this procedure with the exception of a few minor insoluble pigments. The resulting clear supernatants were then diluted one to three with a potassium chloride solution so that the final salt concentration was about 0.1 molar to stabilize the heme pigments. Spectra of the solution were plotted by a Beckman DK recording spectrophotometer.

A consumer type panel of 18 members rated randomly selected samples from each treatment in both experiments on the 9-point hedonic scale.

RESULTS AND DISCUSSION

Observations on the gross changes in color, odor, and texture were as follows: A sulfide or mercaptan-like odor was predominant in all grades at all aging temperatures after irradiation at 2 megarad. At 4 megarad, a "wet grain" type odor was dominant. The samples at 8 megarad had a slight burnt odor along with the "wet grain" type. Aging, especially at higher temperatures, produced a soft texture at low

TABLE 1

Proximate analysis of meat samples

Grade of meat	Moisture	Fat	Protein
	%	%	%
Experiment 1			
Prime	68.5	9.3	20.2
Good	72.6	4.2	23.1
Utility	73.5	2.8	22.9
Experiment 2			
Prime	68.7	10.2	20.5
Good	73.0	4.5	21.9
Utility	72.1	6.4	21.2

[a] Journal Paper No. 175 American Meat Institute Foundation. Journal Article No. 2405 Michigan Agricultural Experiment Station, East Lansing, Michigan.

[b] Presented at the 18th Annual Meeting of the Institute of Food Technologists, May 1958.

[c] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, QM Research and Engineering Command, U. S. Army, and has been assigned Number 970 in the series of papers approved for publication.

radiation dosages (2 and 4 megarad), but at 8 megarad the texture was somewhat rubbery. In all these samples the color was a darker red than the unirradiated controls.

After 3 months storage at 35° F., the odor at 2 megarad was that of the "wet grain" type with a trace of the sulfur type present. At higher dosages and higher storage temperatures the samples were very rubbery in texture, with considerable quantities of drip, and had a "barnyard" odor. The color was a light tan both on the surface and internally, with the exception of those samples which received an 8 megarad dosage and stored at 90° F. where the surface was a greenish black. The cause for the formation of this unusual color cannot be definitely stated, but was, at least in part, due to the effect of storage temperature. Only the samples which received an 8 megarad dosage and stored at 90° F. had the greenish black surface color. Samples which received the same radiation dosage but stored at 35° and 60° F. were light tan in color.

Although the amount of heme pigment obtained by extraction varied between the three grades of meat, there was no positive correlation between grade and pigment. Results of the factors studied showed no significant differences between grades. Of these factors studied, only irradiation dosage and storage at 90° F. had any important effect on the heme pigments. Since the results for 3 grades are substantially the same, only the results for the *good* grade are presented (Table 2).

Effects of irradiation could be classified as 3 types which correlated well with dosage: 1) At 2 megarad, little or no effect on the basic keeping qualities of the pigments. 2) At 4 megarad, sterilization of the samples resulting in good color stability. 3) At 8 megarad, sterilization plus color destruction.

In the controls and in about half of the samples irradiated at 2 megarad, the pigments changed from the original oxymyoglobin to mixtures of pigments containing 25 to 90% metmyoglobin when stored at 35 or 60° F. This change is due either to some bacterial action or to the conversion of oxymyoglobin to metmyoglobin which occurs at low oxygen tensions and *(9)* which has been shown to develop as a result of cell metabolism in an air-tight system. At 4 megarad and, in some cases, at 2 megarad a bright red pigment was formed, similar to oxymyoglobin in spectral characteristics, which proved to be stable upon subsequent storage at 35 or 60° F. Pigment loss upon irradiation or storage of these samples was very slight, being on the average less than 5%.

At 8 megarad about 30% of the heme pigments were destroyed regardless of grade or pre-irradiation storage, but the remaining pigments were all of a satisfactory stable red color.

Post-irradiation storage at 90° F. proved to have the greatest effect on the heme pigments. None of the irradiation dosages given prevented extensive loss of pigment, which amounted from 50 to 80% with the greater losses occurring at higher irradiation dosages. If the storage losses of pigment are compared with the amount of pigment remaining immediately after irradiation, the pigment losses are about equal for all samples stored at 90° F. No significant differences between storage at 35° or 60° F. could be noted except that an occasional sample stored at 60° F. would convert to metmyoglobin when irradiated at 4 megarad.

Pre-irradiation aging, although it did result in some (0–10%) loss of pigment, had no major effect on the type or amount of pigments produced by irradiation. The pigment in samples aged at 45° F. was generally bright red (oxymyoglobin) but that in samples aged at 0° or 30° F. was a mixture containing 50–60% metmyoglobin. Regardless of the pre-irradiation pigment distribution, irradiation resulted in the production of the bright red irradiated pigment.

The spectra of the extracts immediately after irradiation showed a small peak or shoulder at 616 mμ indicative of a small amount of irradiation-produced

TABLE 2

The effect of irradiation on the kind and quantities of heme pigments of good grade beef subjected to various pre- and post-irradiation treatments

Aging conditions		Storage		Irradiation dosage X10⁶ rad							
				0		2.0		4.0		8.0	
Time weeks	Temp. °F.	Time months	Temp. °F.	E_{525}	R[1]	E_{525}	R	E_{525}	R	E_{525}	R
0	....	0	....	.440	1.05	.400	1.61	.360	1.98	.300	2.00
0	....	3	0	.440	1.48						
3	0	0	....	.520	.93					.310	1.89
	35			.485	.99	.485	1.65				
	45			.450	1.23			.380	1.95		
		3	35			.382	.73	.500	1.28	.300	1.75
			60			.382	1.60	.325	.89	.233	.77
			90			.233	1.13	.107	1.19	.127	1.35
3	0	3	35							.435	1.49
			60							.250	1.80
			90							.150	1.46
3	35	3	35			.428	1.21				
			60			.175	.91				
			90			.100	1.09				
3	45	3	35					.300	1.50		
			60					.254	1.57		
			90					.157	1.85		

[1] R = E_{540}/E_{525} where E_{540} is the measure of the red irradiation-produced pigment and E_{525} measures the amount of metmyoglobin.

TABLE 3

The effect of irradiation on the amount of hydrogen sulfide from beef of different grades subjected to various pre- and post-irradiation treatments

	Aging conditions		Storage conditions		Irradiation dosage X10⁶ rad							
					0		2.0		4.0		8.0	
	Time weeks	Temp. °F.	Time months	Temp. °F.	1[1]	2	1	2	1	2	1	2
					μg./g.	μg./g.	μg./g.	μg./g.	μg./g.	μg./g.	μg./g.	μg./g.
Prime	0	....	0	....	0.05	0.00	1.49	0.86	2.12	1.75	2.84	1.79
	3	0	0	....	0.06	0.04			2.36	1.20		
	3	35	0	....	0.16	0.00					2.74	1.63
	3	45	0	....	0.34	0.08	0.86	0.78				
	0	....	3	0	0.21	0.00						
	0	....	3	35			0.79	0.80	0.98	1.35	1.87	1.35
	0	....	3	60			0.96	0.80	0.40	0.72	0.64	0.84
	0	....	3	90			0.28	1.04	0.21	0.40	0.17	0.36
	3	0	3	0	0.16	0.00						
	3	35	3	0		0.00						
	3	45	3	0		0.80						
	3	0	3	35					1.04	0.72		
	3	35	3	35							1.58	1.12
	3	45	3	35			0.44	0.76				
	3	0	3	60					0.84	0.72		
	3	35	3	60							1.23	0.88
	3	45	3	60			1.02	0.56				
	3	0	3	90					0.50	0.36		
	3	35	3	90							0.36	0.14
	3	45	3	90			0.22	1.04				
Good	0	....	0	....	0.15	0.12	1.07	1.00	2.28	1.79	3.21	2.58
	2	0	0	....	0.14	0.00					3.36	1.79
	3	35	0	....	0.17	0.00	1.05	0.60				
	3	45	0	....	0.26	0.00			1.43	1.32		
	0	....	3	0	0.04	0.08						
	0	....	3	35			0.84	0.76	1.37	1.08	1.67	1.99
	0	....	3	60			0.66	0.68	0.96	1.00	1.03	0.86
	0	....	3	90			0.38	0.76	0.04	0.60	0.19	0.20
	3	0	3	0		0.04						
	3	35	3	0	0.04	0.04						
	3	45	3	0		0.08						
	3	0	3	35							2.09	1.60
	3	35	3	35			1.00	0.80				
	3	45	3	35					1.42	0.60		
	3	0	3	60							1.18	0.40
	3	35	3	60			0.94	0.76				
	3	45	3	60					1.02	0.20		
	3	0	3	90							0.24	0.24
	3	35	3	90			0.70	0.62				
	3	45	3	90					0.46	0.16		
Utility	0	....	0	....	0.15	0.00	1.07	0.65	1.56	1.20	3.81	2.05
	3	0	0	....	0.12	0.04	1.40	0.92				
	3	35	0	....	0.13	0.02			2.66	1.66		
	3	45	0	....	0.14	0.02					3.36	1.98
	0	....	3	0	0.08	0.00						
	0	....	3	35			0.14	0.64	0.26	1.12	0.68	1.34
	0	....	3	60			0.18	0.48	0.30	0.88	0.56	0.72
	0	....	3	90			0.24	0.12	0.32	0.04	0.25	0.20
	3	0	3	0		0.00						
	3	35	3	0		0.00						
	3	45	3	0	0.08	0.00						
	3	0	3	35			0.78	0.90				
	3	35	3	35					1.72	1.67		
	3	45	3	35							2.02	1.91
	3	0	3	60			0.86	0.50				
	3	35	3	60					1.07	0.52		
	3	45	3	60							1.32	0.56
	3	0	3	90			0.70	0.44				
	3	35	3	90					0.85	0.14		
	3	45	3	90							0.73	0.14

[1] Experiment number.

sulfmyoglobin *(10)*. Upon aging at any temperature, this green pigment was no longer extractable, but the insoluble material left from the extraction had a faint greenish tinge.

From these results, the main effect of irradiation would appear to be in the production of a red pigment which is more stable to alteration or destruction either because of its own inherent stability or because of the conditions in the irradiated sample. The principal routes of heme pigment destruction do not appear to be of bacterial origin since irradiation sterilization of the samples does not appreciably decrease the extensive destruction of heme pigments which occurs upon 90° F. storage. This is further substantiated by the observation that pre-irradiation storage at 45° F. does not appreciably decrease the amount of extractable heme pigments in spite of extensive bacterial growth. The principal deleterious effect on meat color due to irradiation is in the destruction of heme pigment, especially at sterilizing dosages, but the per cent destruction is usually so small as to be insignificant.

A compilation of the analytical results obtained is given in Tables 3 to 5. Examples of the changes in glycogen content and of pH are given in Tables 7 and 8. These results were not amenable to statistical analysis, because, for glycogen, all values were zero after 3 months' storage, and for pH the changes were too small.

TABLE 4

The effect of irradiation on the amount of methyl mercaptan from beef of different grades subjected to various pre- and post-irradiation treatments

Grade	Aging conditions		Storage conditions		Irradiation dosage X10⁶ rad							
					0		2.0		4.0		8.0	
	Time weeks	Temp. °F.	Time months	Temp. °F.	1[1]	2	1	2	1	2	1	2
					μg./g.	μg./g.	μg./g.	μg./g.	μg./g.	μg./g.	μg./g.	μg./g.
Prime	0	....	0	....	0.08	0.00	0.69	0.27	1.18	1.18	2.04	1.34
	3	0	0	....	0.05	0.13			0.71	1.07		
	3	35	0	....	0.07	0.00					1.47	1.69
	3	45	0	....	0.10	1.65	0.55	1.07				
	0	....	3	0	0.13	0.25						
	0	....	3	35			0.26	0.20	0.44	0.63	0.88	1.20
	0	....	3	60			0.33	0.35	0.46	0.44	0.74	0.60
	0	....	3	90			0.40	0.40	0.50	0.35	0.44	0.46
	3	0	3	0	0.10	0.00						
	3	35	3	0		0.00						
	3	45	3	0		0.95						
	3	0	3	35					0.63	0.54		
	3	35	3	35							1.18	1.10
	3	45	3	35			0.39	0.60				
	3	0	3	60					0.28	0.33		
	3	35	3	60							0.54	0.63
	3	45	3	60			0.25	1.75				
	3	0	3	90					0.63	0.14		
	3	35	3	90							0.80	0.15
	3	45	3	90			0.75	1.67				
Good	0	....	0	....	0.49	0.00	1.25	0.35	2.11	0.68	3.19	1.52
	3	0	0	....	0.23	0.00					4.09	2.60
	3	35	0	....	0.28	0.06	1.56	0.45				
	3	45	0	....	0.34	0.00			2.44	1.44		
	0	....	3	0	0.00	0.33						
	0	....	3	35			0.23	0.20	0.63	0.46	1.20	1.03
	0	....	3	60			0.26	0.20	0.40	0.33	0.78	0.54
	0	....	3	90			0.40	0.33	0.50	0.25	0.50	0.54
	3	0	3	0		0.10						
	3	35	3	0	0.00	0.10						
	3	45	3	0		0.20						
	3	0	3	35							1.16	1.28
	3	35	3	35			0.22	0.22				
	3	45	3	35					1.18	0.50		
	3	0	3	60							0.70	0.85
	3	35	3	60			0.26	0.33				
	3	45	3	60					0.46	0.23		
	3	0	3	90							0.34	0.60
	3	35	3	90			0.36	0.14				
	3	45	3	90					0.36	0.33		
Utility	0	....	0	....	0.06	0.33	0.77	0.88	1.84	1.41	2.74	2.08
	3	0	0	....	0.14	0.00	1.03	0.46				
	3	35	0	....	0.18	0.13			2.21	1.40		
	3	45	0	....	0.21	0.06					3.34	2.15
	0	....	3	0	0.16	0.00						
	0	....	3	35			1.51	0.33	2.76	0.40	1.95	1.00
	0	....	3	60			1.65	0.20	1.28	0.33	1.59	0.58
	0	....	3	90			0.56	0.15	0.60	0.13	0.23	0.40
	3	0	3	0		0.05						
	3	35	3	0		0.13						
	3	45	3	0	0.20	0.15						
	3	0	3	35			0.26	0.63				
	3	35	3	35					0.45	0.95		
	3	45	3	35							2.10	1.63
	3	0	3	60			0.30	0.13				
	3	35	3	60					0.76	0.34		
	3	45	3	60							1.24	0.73
	3	0	3	90			0.41	0.05				
	3	35	3	90					0.64	0.23		
	3	45	3	90							1.75	0.42

[1] Experiment number.

On examination of these results, certain trends were discernible. Increases were observed in hydrogen sulfide, methyl mercaptan, acid-salt soluble carbonyl compounds, and pH attributable to irradiation treatment. The glutathione and glycogen content decreased in all grades with increasing dosages. Pre-irradiation aging, with some exceptions, generally resulted in lower values for hydrogen sulfide, whereas methyl mercaptan values were somewhat higher. Small increases in pH also occurred. Pre-irradiation aging effects on glutathione were not consistent, but glutathione generally increased with higher aging temperatures. Glycogen decreased on aging as expected.

Storage for 3 months caused decreases for hydrogen sulfide, methyl mercaptan, and acid-salt soluble carbonyl compounds, with greater decreases at higher storage temperatures for all grades and dosages. Small increases in pH also occurred at higher storage temperatures. Glycogen values were all zero. Glutathione levels decreased at low storage temperatures, but increased at higher temperatures. Some values were considerably higher than those originally obtained in the fresh unirradiated meat. This could be attributed to proteolysis.

Combined aging and storage effects resulted in a further decrease in hydrogen sulfide, methyl mercaptan, and acid-salt soluble carbonyls in all grades and at all dosages. The effects on glutathione were

TABLE 5

The effect of irradiation on total glutathione in beef of different grades subjected to various pre- and post-irradiation treatments

Grade	Aging conditions		Storage conditions		Irradiation dosage X10⁶ rad							
					0		2.0		4.0		8.0	
	Time weeks	Temp. °F.	Time months	Temp. °F.	1[1]	2	1	2	1	2	1	2
					mg./100 g.	mg./100 g.	mg./100 g.	mg./100 g.	mg./100 g.	mg./100 g.	mg./100 g.	mg./100 g.
Prime	0	....	0	....	16.5	17.1	6.3	11.3	5.4	8.8	5.8	8.1
	3	0	0	....	17.8	15.4			6.3	8.5		
	3	35	0	....	17.8	22.6					5.4	6.3
	3	45	0	....	20.0	27.5	11.3	11.3				
	0	....	3	0	14.4	12.8						
	0	....	3	35			7.0	4.0	5.8	3.8	6.0	4.0
	0	....	3	60			7.5	4.0	7.0	7.0	6.5	3.3
	0	....	3	90			15.3	17.1	13.5	13.0	9.6	8.3
	3	0	3	0	9.5	13.3						
	3	35	3	0		17.5						
	3	45	3	0		19.0						
	3	0	3	35					5.5	6.3		
	3	35	3	35							5.0	6.6
	3	45	3	35			11.9	13.4				
	3	0	3	60					6.8	9.3		
	3	35	3	60							9.5	6.3
	3	45	3	60			21.1	8.3				
	3	0	3	90					8.8	12.0		
	3	35	3	90							8.1	8.3
	3	45	3	90			46.6	26.5				
Good	0	....	0	....	17.3	25.6	10.0	13.5	8.3	12.0	6.3	10.3
	3	0	0	....	17.8	18.4					6.3	6.8
	3	35	0	....	18.1	26.8	11.0	10.3				
	3	45	0	....	14.8	28.8			8.3	8.3		
	0	....	3	0	20.0	24.5						
	0	....	3	35			4.6	5.5	3.5	4.6	4.5	5.5
	0	....	3	60			5.8	7.5	4.5	7.4	3.3	5.8
	0	....	3	90			10.8	9.4	10.8	11.3	8.3	8.9
	3	0	3	0		17.6						
	3	35	3	0	16.0	15.3						
	3	45	3	0		17.9						
	3	0	3	35							5.8	4.3
	3	35	3	35			7.5	2.0				
	3	45	3	35					2.5	6.6		
	3	0	3	60							7.5	5.3
	3	35	3	60			8.8	6.3				
	3	45	3	60					5.6	9.1		
	3	0	3	90							7.5	6.8
	3	35	3	90			8.5	7.8				
	3	45	3	90					12.8	15.9		
Utility	0	....	0	....	10.8	16.1	6.3	9.5	4.4	8.8	2.9	7.5
	3	0	0	....	15.3	15.8	9.4	10.0				
	3	35	0	....	20.0	21.0			7.5	9.8		
	3	45	0	....	17.8	21.0					6.9	7.5
	0	....	3	0	13.8	13.8						
	0	....	3	35			4.5	3.0	3.0	5.4	3.5	5.1
	0	....	3	60			5.5	4.8	4.5	4.6	5.0	5.0
	0	....	3	90			15.3	14.9	12.9	11.4	9.9	7.5
	3	0	3	0		11.5						
	3	35	3	0		12.6						
	3	45	3	0	10.8	17.0						
	3	0	3	35			3.4	7.6				
	3	35	3	35					5.3	8.3		
	3	45	3	35							5.8	5.9
	3	0	3	60			5.8	7.0				
	3	35	3	60					6.1	10.8		
	3	45	3	60							6.0	5.9
	3	0	3	90			11.1	15.9				
	3	35	3	90					14.4	12.6		
	3	45	3	90							13.1	10.0

[1] Experiment number.

similar to storage alone although the values were higher. Small increases in pH also occurred (about 0.1 units).

Statistical analyses of the treatment effects on hydrogen sulfide, methyl mercaptan, carbonyl compounds, and glutathione are listed in Table 9. For all these compounds, the effects of storage condition (time and temperature) and dosage were significant. In addition, aging time and temperature were significant for glutathione. Analyses for interaction of the variables indicated no significant interactions between treatments.

Beef samples irradiated at 2 megarad were evaluated by a taste panel. Both freshly irradiated samples and samples stored at 60° F. for 3 months after irradiation were compared to controls receiving no irradiation and stored for equivalent times at 0° F. Results are shown in Table 7. These results indicate that in the first experiment with fresh meat, irradiation did not significantly influence acceptability, although there was a tendency to score the unirradiated samples somewhat higher. There was also a significant difference between grades; *utility* was less acceptable than either *good* or *prime*. In the second experiment

TABLE 6

The effect of irradiation on carbonyls from beef of different grades subjected to various pre- and post-irradiation treatments

Grade	Aging conditions		Storage conditions		Irradiation dosage X10⁶ rad							
					0		2.0		4.0		8.0	
	Time weeks	Temp. °F.	Time months	Temp. °F.	1[1]	2	1	2	1	2	1	2
					X10⁻⁵ M/g.	X10⁻⁵ M/g.	X10⁻⁵ M/g.	X10⁻⁵ M/g.	X10⁻⁵ M/g.	X10⁻⁵ M/g.	X10⁻⁵ M/g.	X10⁻⁵ M/g.
Prime	0	....	0	....	2.6	5.0	9.4	9.8	15.6	14.5	23.3	20.9
	3	0	0	....	2.8	2.9			14.5	13.3		
	3	35	0	....	8.5	2.2					20.9	20.1
	3	45	0	....	7.0	2.0	14.2	9.2				
	0	....	3	0	4.0	4.5						
	0	....	3	35			6.3	8.3	11.3	11.9	20.9	19.3
	0	....	3	60			4.2	6.3	8.8	8.1	14.2	14.3
	0	....	3	90			5.1	5.4	5.8	6.3	8.6	9.7
	3	0	3	0	12.6	3.6						
	3	35	3	0		2.2						
	3	45	3	0		2.1						
	3	0	3	35					10.6	12.1		
	3	35	3	35							19.6	17.5
	3	45	3	35			7.7	4.5				
	3	0	3	60					8.2	7.1		
	3	35	3	60							12.8	10.7
	3	45	3	60			5.8	3.8				
	3	0	3	90					6.9	5.2		
	3	35	3	90							9.0	7.6
	3	45	3	90			6.8	7.8				
Good	0	....	0	....	3.5	1.8	13.1	9.3	16.1	12.9	21.1	20.2
	3	0	0	....	5.2	4.9					21.9	23.9
	3	35	0	....	13.1	3.0	15.6	10.9				
	3	45	0	....	6.4	4.5			16.1	18.1		
	0	....	3	0	2.5	2.7						
	0	....	3	35			5.6	5.0	11.7	12.3	18.9	20.9
	0	....	3	60			3.2	3.2	8.4	6.9	12.2	11.6
	0	....	3	90			4.1	4.0	6.2	5.4	8.6	7.9
	3	0	3	0		2.8						
	3	35	3	0	9.5	1.9						
	3	45	3	0		2.5						
	3	0	3	35							17.4	18.4
	3	35	3	35			6.9	8.8				
	3	45	3	35					13.6	8.8		
	3	0	3	60							11.5	13.1
	3	35	3	60			5.4	3.3				
	3	45	3	60					9.2	4.9		
	3	0	3	90							8.0	9.0
	3	35	3	90			5.9	5.5				
	3	45	3	90					7.0	7.6		
Utility	0	....	0	....	4.7	3.9	14.2	10.7	14.5	17.0	20.9	23.5
	3	0	0	....	3.3	5.4	10.8	12.7				
	3	35	0	....	5.3	4.4			17.3	21.2		
	3	45	0	....	3.3	4.2					22.4	26.5
	0	....	3	0	2.6	2.9						
	0	....	3	35			7.3	6.2	12.3	12.1	13.3	19.0
	0	....	3	60			5.4	3.3	10.1	7.1	13.0	13.6
	0	....	3	90			4.6	4.0	5.1	5.0	5.8	7.8
	3	0	3	0		4.2						
	3	35	3	0		2.8						
	3	45	3	0	8.0	3.0						
	3	0	3	35			7.1	10.6				
	3	35	3	35					13.3	12.6		
	3	45	3	35							19.6	19.3
	3	0	3	60			5.0	4.7				
	3	35	3	60					10.2	9.6		
	3	45	3	60							12.7	15.5
	3	0	3	90			5.5	5.3				
	3	35	3	90					7.5	6.6		
	3	45	3	90							8.5	9.3

[1] Experiment number.

only *prime* showed no significane in preference. In *good* and *utility*, the unirradiated samples were significantly more acceptable than irradiated samples. Also, in this experiment, *prime* was significantly more acceptable gradewise than *utility*, whereas, *good* was not significantly different from either. After 3 months' storage, all non-irradiated samples were rated significantly higher than their irradiated counterparts. Of interest is the observation that with irradiated cooked meat, storage improved taste panel acceptance *(11)*.

Although aging beef prior to irradiation and subsequent storage for 3 months reduced the amount of hydrogen sulfide and methyl mercaptan which contributed to off-odors, other reactions apparently occur at high storage temperatures which are more undesirable on the basis of color and odor than that due to irradiation alone. This is evident from the gross observations and taste panel evaluations. Since the procedure used for the determinations of glutathione will also give positive results with cysteine and other free sulfhydryl groups, the increased values for glutathione on aging and storage are indicative of proteolysis. Nevertheless, it is now recognized by other workers in this field that some method of enzyme inactivation will become an integral part of the irradiation procedure for complete sterilization. This may alter the picture with respect to aging and storage.

TABLE 7

The effect of irradiation on the glycogen content of utility grade beef subjected to various pre- and post-irradiation treatments

Aging conditions		Storage conditions		Irradiation dosage X10⁶ rad							
				0		2.0		4.0		8.0	
Time weeks	Temp. °F.	Time months	Temp. °F.	1[1]	2	1	2	1	2	1	2
				mg./g.	*mg./g.*	*mg./g.*	*mg./g.*	*mg./g.*	*mg./g.*	*mg./g.*	*mg./g.*
0	....	0	....	0.55	0.44	0.28	0.26	0.17	0.17	0.15	0.13
3	0	0	....	0.28	0.54	0.08	0.33				
3	35	0	....	0.74	0.90			0.24	0.27		
3	45	0	....	0.42	0.57					0.10	0.22
0	....	3	....	0.24	0.72						

All other values were zero.
[1] Experiment number.

TABLE 8

The effect of irradiation on pH of utility grade beef subjected to various pre- and post-irradiation treatments

Aging conditions		Storage conditions		Irradiation dosage X10⁶ rad							
				0		2.0		4.0		8.0	
Time weeks	Temp. °F.	Time months	Temp. °F.	1[1]	2	1	2	1	2	1	2
				pH values	*pH values*	*pH values*	*pH values*	*pH values*	*pH values*	*pH values*	*pH values*
0	....	0	....	5.50	5.45	5.55	5.50	5.62	5.55	5.80	5.65
3	0	0	....	5.59	5.52	5.66	5.60				
3	35	0	....	5.71	5.62			5.87	5.85		
3	45	0	....	5.70	5.52					5.95	6.00
0	....	3	0	5.30	5.50						
0	....	3	35			5.55	5.70	5.60	5.75	5.70	5.70
0	....	3	60			5.60	5.70	5.68	5.70	5.75	5.70
0	....	3	90			5.95	5.80	5.95	5.85	5.98	5.50
3	0	3	0		5.50						
3	35	3	0		5.60						
3	45	3	0	5.60	5.65						
3	0	3	35			5.80	5.63				
3	35	3	35					5.83	5.70		
3	45	3	35							5.98	5.90
3	0	3	60			5.90	5.70				
3	35	3	60					5.93	5.75		
3	45	3	60							6.09	6.13
3	0	3	90			6.10	5.90				
3	35	3	90					6.15	5.90		
3	45	3	90							6.25	6.25

[1] Experiment number.

TABLE 9

Summation of analysis of variance on chemical changes in beef of different grades subjected to various pre- and post-irradiation treatments

Source of variation	Degrees of freedom	Sum of squares	Mean square	F. ratio	Significance
Hydrogen Sulfide					
Aging time	1	0.17	0.17	1.55	None
Aging temperature	2	0.18	0.18	<1	None
Grade	2	0.13	0.07	<1	None
Replicate	1	1.73	1.73	15.73	0.1% level
Storage Condition[1]	3	38.36	12.79	116.27	0.1% level
Dosage	2	8.17	4.09	37.18	0.1% level
Methyl Mercaptan					
Aging time	1	0.27	0.27	1.59	None
Aging temperature	3	2.24	0.75	4.41	None
Grade	2	2.13	1.07	5.68	None
Replicate	1	3.78	3.78	22.23	0.1% level
Storage Condition[1]	3	24.40	8.13	47.82	0.1% level
Dosage	2	12.53	6.27	36.88	0.1% level
Glutathione					
Aging time	1	106.49	106.49	22.23	0.1% level
Aging temperature	3	338.24	112.74	23.53	0.1% level
Grade	2	11.93	5.97	2.20	None
Replicate	1	2.1	2.1	<1	None
Storage Condition[1]	3	1040.43	346.81	72.40	0.1% level
Dosage	2	294.66	147.33	30.75	0.1% level
Carbonyl Content					
Aging time	1	16.01	16.01	9.88	None
Aging temperature	2	23.15	11.13	6.87	None
Grade	2	7.06	3.53	2.09	None
Replicate	1	2.07	2.07	1.28	None
Storage Condition[1]	3	2124.41	708.14	437.12	0.1% level
Dosage	2	1698.01	849.01	524.08	0.1% level

[1] Time and temperature.

TABLE 10

Panel scores as influenced by grade, irradiation, and storage on beef

	Mean panel scores					
	Fresh beef			3 months storage		
	Prime	Good	Utility	Prime	Good	Utility
1st. Experiment						
Unirradiated	5.85	5.25	4.65	6.30	5.75	5.15
2 megarad	5.00	5.40	4.00	4.20	3.65	3.05
Grade means	5.42[2]	5.33[2]	4.33	5.25[2]	4.70[1]	4.10[2]
2nd. Experiment						
Unirradiated	4.75	4.95[2]	4.55[2]	5.25	5.55	5.85
2 megarad	4.45	3.00	2.85	2.85	3.25	3.65
Grade means	4.60[1]	3.97	3.70[1]	4.05[2]	4.40[2]	4.75[2]

[1] Difference significant at 5% level.
[2] Difference significant at 1% level.

On the basis of the results obtained in these experiments, it would appear that nothing is to be gained in acceptability by pre-irradiation aging and post-irradiation storage of fresh meat irradiated in the sterilizing dosage range.

SUMMARY

The effects of pre-irradiation aging time and temperature and post-irradiation storage time and temperature on some of the chemical changes which occurred in irradiated fresh beef were studied. Chemical changes were, in general, influenced by these treatments. Some combinations enhanced the degree of change while other combinations decreased the apparent value. Analysis of the data indicated storage conditions and irradiation dosage had the most significant effect on the degree of these changes.

Observations on color and odor changes and on taste panel evaluation indicated no improvement in acceptability of the product by pre-irradiation aging and post-irradiation storage.

Acknowledgments

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The Influence of Sodium Chloride On Toxin Production and Organoleptic Breakdown In Perishable Cured Meat Inoculated With *Clostridium Botulinum*

(Manuscript received April 4, 1959)

Richard A. Greenberg, John H. Silliker and Louis D. Fatta

Research Laboratories, Swift & Co., Chicago, Illinois

PRIOR TO THE ADVENT of mechanical refrigeration, meats were cured with sufficient levels of salt to impose stability. The "hard" cure lost favor gradually as the public appetite began to show preference for progressively milder flavor in cured products. Today, most cured meats — hams, corned beef, sausages, etc.—are cured for the palate, not for stability.

Packers combine thermal processing with mild curing to produce shelf-stable products *(9)*. The bulk of cured meats are, however, given cooks insufficient to render them shelf-stable. Here, proper refrigertion is an absolute necessity in protecting quality and safety. The possibility that perishable cured meat products might be mishandled by the retailer or consumer is ever present. It is thus extremely important that the consumer have warning that a given package of product has been improperly handled and, therefore, potentially hazardous. The primary danger is, of course, that *Clostridium botulinum* might produce toxin without obvious organoleptic breakdown. Fresh uncured meats, inoculated with *Cl. botulinum* undergo obvious putrefaction before they become toxic *(4)*. Segalove and Dack *(8)* observed the same phenomenon in rehydrated dried beef and pork.

Examination of incubated inoculated products containing a variety of curing systems demonstrated that putrefaction also precedes toxin development in mildly cured meats *(5)*. The curing systems studied included combinations of sodium chloride, sodium nitrate, and sodium nitrite at concentrations usually obtained in perishable cured meats (3.00–5.65% brine, 0–624 p.p.m. sodium nitrate, 78 p.p.m. sodium nitrite).

The present study, undertaken to investigate the minimal level of sodium chloride capable of preventing toxin production in perishable cured meat, revealed that certain sodium chloride concentrations allow toxin formation in the absence of organoleptic deterioration.

MATERIALS AND METHODS

Product preparation. Beef hams were ground through a ⅜ in. plate and vacuum mixed with the addition of sodium chloride and sodium nitrite. After being held overnight at 40° F., the products were mixed under 25–27 inches of vacuum and stuffed in 6-lb. luncheon meat cans (4⅛ x 5⅝ x 12½ inches). Cooking consisted of a 3¼ hour processing at 170° F. Chemical analyses of the product variables after cooking are listed in Table 1.

TABLE 1

Chemical analyses of product variables before incubation

Code	NaCl	H_2O	Brine	$NaNO_3$
	%	%	%	*p.p.m.*
A	2.1	67.4	3.00	22
B	2.2	67.7	3.02	16
C	3.5	64.6	5.14	21
D	4.3	64.5	6.25	14
E	5.1	66.8	7.09	12
F	5.0	65.2	7.12	22
G	6.4	65.1	8.95	11
H	7.5	58.7	11.49	12

Inoculum. The spore inoculum contained approximately equal numbers of the following National Canners Association strains of *Cl. botulinum:*

Type A: Strain numbers 62, 73, 78, 12885, 13824

Type B: Strain numbers 32, 112, 213, 12033, 13983

Prickett tube counts in Anderson Pork Infusion Agar showed that the suspension contained approximately 920,000 viable spores per gram following heat shock at 185° F. for 10 minutes.

Inoculation and packaging. Each 6 lb. loaf was sliced into ⅜ in. sections. Ten-gram circular wafers were then prepared from the slices by means of a cookie cutter of appropriate shape and size. The wafers were individually packed in thermal death time cans, inoculated with 0.1 ml. of the heat shocked *Cl. botulinum* spore suspension using a 1 ml. tuberculin syringe and 26 gauge needle, and closed with undercover nitrogen gassing *(6)*. The *Cl. botulinum* spore concentration in each test can was approximately 9,200 per gram of product.

Incubation. All cans were incubated at 85–100° F. until swells developed, at which time they were frozen for subsequent examination. Incubation of unswollen cans was terminated after 90 days.

Organoleptic evaluation. The contents of each can were allowed to thaw at room temperature and observed for odor and appearance.

Toxin determination. The contents of each can were shaken with 20 ml. of sterile water. The suspensions obtained were held 24–48 hours at 36–40° F. to permit settling of particulate material. Swiss strain white mice were challenged by intraperitoneal injection of 0.25 ml. of the supernatant liquid. Death within 4 days was considered presumptive evidence of toxin in the sample. All presumptively toxic filtrates were confirmed by protection testing with polyvalent (ABC) *Cl. botulinum* antitoxin. Those fluids which did not kill animals protected with an equal quantity of antitoxin, but again destroyed unprotected control mice, were considered to be confirmed positives.

RESULTS

The study revealed that at certain brine concentrations, *Cl. botulinum* toxin was elaborated in product displaying no sign of spoilage. The data are presented in Table 2. No incidence of toxicity without obvious organoleptic degradation was found in the product containing up to 5.14% brine. At 6.25% brine, the majority of samples were decomposed and putrid or cheesy. The contents of 14 of the 132 cans examined (10.6%) were, however, softened but otherwise sound. Nine of these samples were toxic. Of 103 cans packed in variable E (7.09% brine), 6 contained some olfactory sign of putrefaction. Although completely sound visually, three were toxic. The remaining samples, 97 in number, were normal in odor and appearance. Thirteen of these contained toxin. Similar results were observed in product containing 7.12% brine product where

TABLE 2

Effect of salt (brine) on Clostridium botulinum toxin formation and organoleptic condition of perishable cured meat

Code	Brine	No. cans examined	Organoleptic condition	No. cans toxic
	%			
A	3.00	102	All putrid and decomposed	19/20
B	3.02	103	All putrid and decomposed	19/20
C	5.14	101	All decomposed and putrid or cheesy	14/20
D	6.25	132	118 decomposed and putrid or cheesy	94/118
			14 softened not putrid or cheesy	9/14
E	7.09	103	6 slightly putrid, firm texture	3/6
			97 normal	13/97
F	7.12	104	All normal	14/104
G	8.95	103	All normal	0/103
H	11.40	102	All normal	0/102

14 toxic samples occurred in the absence of organoleptic breakdown. Thus, at the 7.09 and 7.12% brine levels, 27 cans out of 201 showing no organoleptic evidence of microbial activity (13.4%) contained *Cl. botulinum* toxin.

The significance of these findings was illustrated by a subsequent experiment. A batch of fresh 1½ lb. ham pieces were subjected to a curing protocol designed to impose a minimum brine concentration of 5.5% in each piece. This was accomplished by submerging the pieces in curing pickle of appropriate composition. The meat, equipment and curing technology utilized in this study were typical of the best to be found in the modern commercial plant. Upon completion of the curing period, the same pieces were analyzed for sodium chloride and moisture content.[a]

The results summarized in Table 3 showed a final brine concentration ranging from 5.30 to 8.35%. Twenty of the 41 pieces contained over 6.0% brine; six pieces fell below 5.5%.

DISCUSSION

The finding of toxin in cured meat containing relatively high concentrations of sodium chloride is not surprising. The results are predictable when one reviews the literature covering the effect of sodium chloride *on Cl. botulinum*. Tanner and Evans *(11)* concluded that salt is the most active preservative used in meat curing solutions. However, their data showed that 5 of the 6 *Cl. botulinum* strains studied required 8.5 to 10.5% salt for complete suppression. The data of Bulman and Ayres *(1)*, Evans and Tanner *(3)*, Scott *(7)*, Stumbo *et al. (10)* and Yesair and Cameron *(12)* also suggest that *Clostridia* are not wholly deterred by brine concentrations above 5.5%.

[a] The authors are indebted to Dr. M. M. Voegeli, Head, Meat Curing Research Division, Swift & Company and Mr. W. R. Schack, Head Canned Meats Research Division, Swift & Company, for design and execution of the experiment.

Toxin production in the absence of obvious bacterial development in high salt environments is also not without precedence in the literature. Tanner and Evans *(11)* reported toxin formation by *Cl. botulinum* without apparent growth in a nutrient medium containing 10.5% sodium chloride.

Whereas experience and the literature have shown that *Cl. botulinum* toxin formation cannot be prevented by organoleptically acceptable levels of sodium chloride, the tendency has been to demand increasing amounts of salt because of its delaying effect on the appearance of spoilage. If one looks at this study in these terms, he finds that spoilage has been retarded by the presence of 7.1% brine. This sodium chloride level resulted in a completely "stable" pack—but only in terms of the criteria usually relied upon to denote spoilage. Under these high salt conditions, detection of bacterial growth required a biological test. Here, inhibition of *Cl. botulinum* by salt is more apparent than real.

Billions of pounds of large perishable canned hams (over 3 lbs.) have been purveyed to the public with no single reported case of botulism. A primary reason for the excellent public health history of the product is undoubtedly the low level of all putrefactive anaerobic spore-forming bacteria indigenous to it *(2)*. We have during a 3-year study incubated at 85–100° F. more than 1,000 cans of uninoculated perishable canned cured meats for periods of 3 to 12 months. None of these cans, spoiled or unspoiled, contained *Cl. botulinum* toxin as determined by standard mouse protection analysis at termination of incubation.

Since ham containing an excess of 6% brine is judged "salty" by the average consumer, the usual level in canned perishable ham is well below that figure. It is probable that another major factor in the absence of botulism incidence from this product category is that its mishandling results in obvious organoleptic breakdown. The net effect of this study is the observation that as one surpasses the 6% brine level, this built-in safety factor is negated.

Several questions remain unanswered. How much *Cl. botulinum* growth occurred in organoleptically acceptable toxic product? Do certain levels of sodium chloride restrict specifically putrefactive enzyme formation while permitting toxin development? Does the mechanism involve germination of the spore inoculum followed by osmotically induced lysis? A fundamental understanding of the effect of sodium chloride

TABLE 3

Brine range in 1½ lb. perishable hams cured to contain a minimum of 5.5% brine

Brine range, %	No. of hams	% of hams
5.3–5.4	6	14.6
5.5–6.0	15	36.6
6.1–6.5	6	14.6
6.6–7.0	3	7.3
7.1–7.5	2	4.9
7.6–8.0	5	12.2
8.1–8.35	4	9.8
	41	100.0

on *Cl. botulinum* at the cellular level will have wide application in the food preservation industry.

The findings with respect to the levels of salt which are obtained in attempting to produce a 5.5% brine minimum in hams are quite instructive. Almost 50% of the ham pieces, cured so as to produce a 5.5% minimum, fell into the 6.10–8.35% range. An additional 14% of the pack was found to contain less than 5.5% brine. Similar variation could be expected in attempting to comply with any specific sodium chloride minimum. It is obvious, however, that a very significant percentage of a 5.5% brine minimum pack will terminate with sodium chloride concentrations which prevent organoleptic spoilage without precluding *Cl. botulinum* toxin formation.

SUMMARY

Toxin formation by *Cl. botulinum* was observed in inoculated perishable cured meat with no accompanying organoleptic degradation of the product. This occurred in product containing 6.25, 7.09 and 7.12% brine. A batch of 1½ lb. ham pieces, cured to comply with existent safety standards (5.5% brine minimum) showed wide variance when analyzed at termination of cure. Forty-nine per cent of the lot contained brine in the 6.10–8.35% range. Marketing of a perishable product, the mishandling of which could result in *Cl. botulinum* toxin formation without warning to the consumer, could constitute a public health hazard.

The data suggest that in a perishable cured product the level of salt must be within the range wherein botulism toxin formation is attended by obvious organoleptic breakdown (below 6.25% brine). Alternatively the salt level may be such that toxin formation is inhibited (above 9%).

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Use of Coating Materials or Film Impregnated with Chlortetracycline to Enhance Color and Storage Life of Fresh Beef[a, b]

John C. Ayres

Food Processing Laboratory, Iowa State University, Ames, Iowa

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MICROBIOLOGICAL SPOILAGE, discoloration and dehydration are the primary factors limiting the storage life of sliced fresh meats. Kraft and Ayres *(11)* reported that incipient spoilage was indicated by an onset of off odor which occurred when surface counts of meat samples approximated 10^7 organisms per cm.^{2}. In many instances they observed discoloration of samples before disagreeable odors were detected. Discoloration of packaged meats has been investigated by a number of workers *(3, 4, 8, 11, 12, 13, 16, 17)*. Butler *et al. (8)* inoculated beef with *Pseudomonas* sp. and found that the inoculated samples showed greater discoloration than did uninoculated controls. These workers considered that the shorter shelf life of the inoculated meat was due to microbial growth.

Several investigators *(1, 2, 9, 10, 18, 19, 20, 21, 22)* have suggested the use of an antibiotic spray or dip or the incorporation of antibiotic into the ground tissue of flesh foods to delay or prevent spoilage. For sliced meats one possible means of applying an antibiotic is to incorporate it into a material used to cover the food product. Such application of one of the tetracyclines enhances the protective effect from spoilage if the antibiotic is applied at the time of packaging so that the food product is not exposed to subsequent contamination by resistant microorganisms. Westveer *(23)* reported on the coating of frozen meat using a hot melt resin. He pointed out the following advantages in using this type of covering[c]:

(1) Clear, transparent, and tough
(2) Easily removed by peeling
(3) Maintains original quality of meat
(4) Skintight
(5) Impermeable to moisture
(6) Protects meat from shopper contamination
(7) Flexible at freezer temperature
(8) Adaptable to automatic process

In 1953 Lovegren and Feuge *(14)* reported that acetostearins were potentially useful as protective coatings and that these acetoglycerides were being evaluated for use with processed and dressed meats *(5)*. Two years later, another report *(6)* indicated that work was in progress wherein this type of dip coating was used to prevent moisture loss and retard development of rancidity of wieners.

Recently Meyer *et al. (15)* indicated that coatings of the marine plant polysaccharides, agar and carrageenin gels, when used as vehicles for applying the water soluble antibiotics, increased shelf life of poultry.

Another possibility in limiting the deteriorative action of spoilage, discoloration and dehydration is to wrap meat in a packaging film impregnated with an antibiotic.

Use of coating materials or films infused with antibiotics may have important significance for the meat industry since most of the organisms are confined to the surface and most spoilage problems are surface phenomena. Also, by conventional methods of cookery, meat usually receives adequate heat treatment to inactivate antibiotic residues at the surface. The following study was undertaken to determine whether or not the storage life of sliced fresh meats could be prolonged by incorporating an antibiotic into a coating material or a packaging film.

EXPERIMENTAL PROCEDURE

Fresh sliced beef was procured from a local retail store at the time of arrival of the carcasses from the processing plant. Both "Budget" and "Choice" steaks were studied. These were obtained from, or near, the center of the round. Care was taken that, after slicing, the adjacent sides of each two slices of round were kept in contact until they could be sampled in the laboratory. With the two slices still in juxtaposition, pieces of lean were cut by means of a sterile knife and then were hand dipped into (1) an experimental hot melt resin, (2) long chain saturated diacetin fat or (3) plasticized agar, and immediately withdrawn and allowed to drain for 15–30 seconds.

The hot melt dip[d] used has an ethylcellulose base and is one of a series of patented (U. S. 2,840,476) formulations covering "hot melts" developed for coating foods. The diacetins[e] are saturated, diacetyl (palmitic-stearic) triglycerides consisting of a mixture of hydrogenated soybean oil derivatives having an iodine value of one and a melting point of 30° C. Preparation of the plasticized agar was described by Meyer *et al. (15)* as follows: to 800 ml. quantities of 3% agar solution, 1% glycerol was added as a plasticizer. Then the mixture was steamed in an autoclave until the coating materials were melted and in solution. The melted coatings were maintained at approximately 65° C. until used.

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[a] Journal Paper No. J-3654 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 1264; Agricultural Adjustment Center, cooperating.

[b] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, May 20, 1959.

[c] Practical use of these agents as edible dips for foods is not permitted at the present time.

[d] Kindly supplied by The Dow Chemical Company, Midland, Michigan.

[e] Supplied through the kindness of the Procter & Gamble Co., Cincinnati, Ohio.

For trials wherein beef was wrapped, the pieces of meat were transferred by sterile forceps to a Rodeo [f] peach prepackaging meat board, packaged in FH-1 Pliofilm [g] and heat sealed. The Goodyear Company formulated and cast the following films used for packaging: FM-1 Pliofilm control and identical films except that they contained 0.4 part chlortetracycline-hydrochloride (CTC-HCl), 0.1 part CTC-HCl or 0.04 part CTC-HCl per 100 parts rubber hydrochloride.

For the bacteriological tests, 5 to 7 matched-pair cuts 4 x 4 x ½ in. were used in order to provide "mirror-image" samples for each of the storage periods. Samples were stored in refrigerated display cases set at 5° C. ± 1, at 10° C. ± 1 and at 15° C. ± 2 except for defrost cycles.

Microbiological samples were made by rolling a moist swab over a known amount of meat surface. Five 2 cm.^{2} areas of each piece of meat were swabbed and the 5 swabs placed in one sterile 2 oz. prescription bottle containing 20 ml. of water. Appropriate serial dilutions were made and 3 sets of nutrient agar plates were prepared in duplicate. The plates were incubated at 5°, 15° or 25° C. for 7, 4 or 2 days respectively; the colonies were counted with the aid of a Quebec colony counter.

For the analysis of color, 12 to 14 matched-pair cuts 1½ x 1½ x ½ in. were selected and placed on packaging boards and packaged in Pliofilm as was described earlier. It was essential to use meat of as uniform color as possible. One muscle section was used for this purpose in order to minimize differences due to direction of muscle striations, marbling and other factors but even these precautions did not always assure that the individual samples had identical coloration. A Beckman Quartz Spectrophotometer, Model DU, equipped with a diffuse reflectance attachment, Model 2580, was used for reflectance measurements; a block of U. S. P. carbonate of magnesia served as the standard. A strip of polystyrene Q-641 film was placed over the meat held in the reflectance attachment in order to prevent meat particles from adhering to the attachment housing. Reflectance readings were obtained at 580 mμ (oxymyoglobin) and 635 mμ (metmyoglobin) since it was found that, in these two regions, the concentrations of the two pigments were at maximum-minimum ratio with respect to each other.

Meat stored at 5° C. was sampled after 0, 1, 2, 3 or 4, 6, 8, 10 and 13 days; that stored at 10° C. was analyzed at 0, 1, 2, 3, 5, and 7 days; that stored at 15° C. was tested at 0, 1, 2, 3, and 4 days.

RESULTS AND DISCUSSION

The hot melt, diacetin fat, and agar with added plasticizer were effective in delaying microbial proliferation. Also, when the coating was peeled from the flesh, many of the bacteria adhered to the covering material. Incorporation of the antibiotic chlortetracycline into the resin, modified fat, or agar further prolonged the time elapsing before microbial populations caused the development of off odor (10^7 organisms per cm.^{2}).

The temperature necessary for dipping fresh meats in a hot melt was so high that there was some surface tissue damage and sufficient coagulation of free juice took place that the meat had a faded or brown discolored appearance. This contrasted with results obtained with frozen meats where, apparently, the frozen film surface provided adequate protective insulation to retard rapid conduction of heat.

The temperature range for the diacetin dip was ideal for refrigerated meats. The modified fat solidified almost immediately after it came in contact with the cold meat forming a non-greasy, wax-like, flexible and close-fitting film. While the thickness of the film was dependent upon the temperature of the melted diacetin fat, thickness of the fat layer usually ranged from 10–15 mils. When the temperature of the meat was maintained at 5° C. and that of the diacetins at 40° C., the dip congealed quickly and there was adequate drainage. Stability of the acetin fats to hydrolysis and their ability to retain moisture were excellent but similar impermeability to the passage of oxygen and other gases was not a desirable characteristic. Meats dipped in this type of edible coating material appeared discolored after storage when compared with those packaged in rubber hydrochloride film.

After solidifying, the layer of agar plus added glycerol usually had a thickness of 30–35 mils. Desiccation of meats coated with plasticized agar was very great and, two days after dipping, samples stored in a refrigerated display case (5° C. ± 1) without an overwrap compared most unfavorably with those coated with hydrogenated diacetins or with the hot melt resin. On the other hand, the color of meats dipped in plasticized agar was much better than for the other two coatings; when an overwrap of Pliofilm was used, meats remained a desirable scarlet red in color for 4 to 5 days. An additional 2 days of storage was obtained when chlortetracycline was impregnated in the agar or when CTC was incorporated in water solutions in which the meat was dipped and overwrapped with Pliofilm.

Since these trials were of a preliminary nature only, no flavor tests were made with any of the coatings. Before any of the dipping agents could be applied to foods, it would first be necessary to determine if these materials are tasty and edible or if they contribute off odor or off flavor to the product.[e]

In their present stage of development, coating agents are not entirely satisfactory for fresh meats. However, since these materials apparently do delay the growth of microorganisms, further work appears warranted. An antibiotic might have value in enhancing the storage life of meats if incorporated in the melted hydrogenated diacetin fat or as a dip immediately before covering with a resin spray. In addition, coatings of hot melt resin or diacetin fat prevent desiccation.

Sliced round steak packaged in Pliofilm and stored at 5° C. developed off odor within 6 days while that wrapped in film containing chlortetracycline (CTC) did not have this defect until the 8th day of storage. By 8 days the control samples had become slimy, a defect not observed on the CTC impregnated film until the 10th day of storage. Packaged steaks stored at 10° C. developed off odor in 3 days while that wrapped in antibiotic film did not have this defect until the 5th day of storage. Similarly, control samples at 10° C. had become slimy by the 4th day while those in films in which chlortetracycline had been incorporated did not give similar manifestation of slime until the 7th day. At a storage temperature of 15° C., disagreeable odors were observed in 2 days in meat packaged in the control film while samples in CTC film reached this condition in 3 days.

[f] Sutherland Paper Co., Kalamazoo, Michigan.

[g] Rubber hydrochloride film made by The Goodyear Tire & Rubber Co., Akron, Ohio.

Numbers of psychrophilic organisms recovered from meats packaged with Pliofilm or with Pliofilm containing CTC are shown in Figure 1 (heavy lines). In these trials the meat was held at 5°, at 10° or at 15° C. and organisms obtained from swab samplings were enumerated from pour plates incubated at 5° C. At each of the 3 temperatures used for storage of the meat, proliferation of organisms in the treated films was delayed when compared with numbers of cells growing on meat in untreated Pliofilm. An inverse relationship was found between the amount of chlortetracycline incorporated in Pliofilm and the numbers of microorganisms recovered from packaged meat. Results are shown in Table 1.

TABLE 1

Number of organisms recovered from meat packaged in films containing chlortetracycline

Parts CTC/100 rubber HCl	Number of organisms x 1000					
	Days of storage					
	0	1	3	6	8	10
0	1.55	1.64	9.4	2,700	48,000[1]	192,000[1]
.04		1.06	7.8	2,050	42,500[1]	175,000[1]
.1		.88	6.7	810	12,400	139,000[1]
.4		.57	2.0	490	5,500	61,000[1]

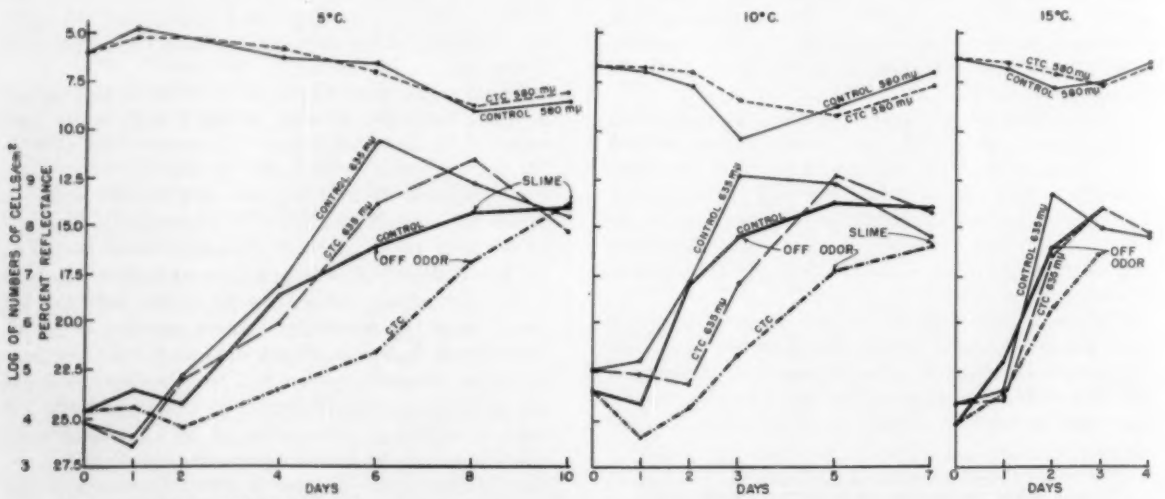
[1] Off odor.

Temperature of storage did not exert profound influence upon differences in numbers of organisms recovered when plates from meat stored at 5° C. were held at 5°, 15° or 25° C. There does appear to be some reduction in the numbers of organisms recovered from meat packaged in Pliofilm when contrasted with that of similar products held in Pliofilm impregnated with CTC. When plates were incubated at 5° C., there was an initial lag in the growth curve and, during the first 10 days of storage, numbers of organisms recovered from meat wrapped in CTC treated Pliofilm were much lower than that on meat packaged in the control film.

At 5° C., areas of discoloration on control pieces of meat packaged in Pliofilm were observed on the 5th day but, generally, two additional days elapsed before similar zones were observed on meat wrapped in Pliofilm into which CTC had been impregnated. Loss of bloom was apparent to the naked eye before minimal changes in reflectance from the meat surface were noted. If reflectance values of less than 12.5 at 635 mμ are considered representative of greatly discolored meat, the control meat stored at 5° C. was unsuitable for use on the 6th day of storage while that wrapped in film containing antibiotic did not reach a similar end point until the 8th day (Figure 1). At 10° C. minimal reflectances were observed on the 3rd day for the controls and on the 4th or 5th day for meat packaged in antibiotic-containing film.

Pirko and Ayres *(16)* tested the effect of storage on reflectance readings from packaged beef and observed that when the percentage reflectance at 580 mμ reached its maximum level, there was a minimum value of 635 mμ. They considered that maximal values for metmyoglobin (635 mμ) occurred at the same time that the minimal oxymyoglobin (580 mμ) and myoglobin (555 mμ) concentrations were obtained. It may be seen in Figure 1 that similar trends are shown in the present study. Since the pattern of change at 555 mμ representing values for myoglobin approximate those shown for oxymyoglobin at 580 mμ, the 555 mμ values are not plotted.

Recently Broumand *et al. (7)* published a procedure which they called the "absorbance ratio method" in which they compared absorbencies of meat extracts prepared from sample determinations at 582, 564 and 544 mμ. Although it is conceivable that these absorbance ratios might give an indication of the proportion and cumulative amounts of heme derivatives in meat, their use in detecting changes at the surface are of little value. Pirko and Ayres *(16)* observed that discoloration of packaged fresh meat is a phenomenon restricted primarily to the upper 2-4



Heavy lines represent bacterial counts.

Figure 1. Numbers of organisms and changes in per cent reflectance on packaged beef during storage at 5°, 10°, or 15° C.

millimeter depth of tissue and that absorption spectrophotometry of pigment extracts cannot be applied in determining discoloration of meats that are limited to these superficial layers alone.

It appears that the incorporation of chlortetracycline into a flexible packaging material such as Pliofilm serves a useful purpose in retarding the growth of microorganisms and in preserving the color on the surface of the meat. Apparently this evidence, in keeping with earlier observations by Butler *et al. (8)*, indicates that there may be an interrelationship between the growth of microorganisms, the development of off odor and slime, and the discoloration of meat.

SUMMARY

When hot melt, diacetin fat, and agar with added plasticizer were used as coating materials for fresh meats, microbial proliferation was retarded. The hot melt and the modified fat prevented desiccation but meats protected with these coatings had undesirable color. A layer of plasticized agar did not prevent excessive drying unless the meats were also overwrapped with film.

Incorporation of chlortetracycline into Pliofilm delayed microbial growth and maintained desired surface color of meat for a longer period of time than did the film alone. An inverse relation was shown between keeping time and temperature of storage. At 5° C., packaged steak wrapped in film containing 0.4 part CTC/100 parts rubber hydrochloride did not develop off odor until 2 days after the control meat had shown similar signs of spoilage. Numbers of organisms proliferating on meat wrapped in CTC treated Pliofilm were invariably less than those on meats packaged in the control film. Temperature of storage of plates had only minor influence on microbial recoveries. Reflectance readings at 580 mμ and 635 mμ indicated a 2-day lag in discoloration for meat packaged in film impregnated with CTC. Studies with film containing smaller amounts of CTC in the rubber hydrochloride base also indicated less rapid microbial proliferation and less discoloration than did the control packages. Maximum-minimum reflectance readings at 580 and 635 mμ for oxymyoglobin and metmyoglobin respectively were not found until bacterial populations had caused off odor.

Acknowledgment

Appreciation is expressed to The Goodyear Tire and Rubber Company, Akron, Ohio, for preparation of the antibiotic impregnated film. Particular thanks are given to Mr. Neil Bulman for his assistance in the preparation of the film. Thanks are also due Mrs. Donna Nixon and Mrs. Nancy Arnold for their technical assistance in conducting the bacteriological work.

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Consumer Preferences for Beef of Different Breeds Related to Carcass and to Quality Grades*

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Marilyn Dunsing

Department of Home Economics, University of California, Davis, California

THE STAMPED CARCASS grade appearing on beef carcasses is a composite evaluation of the three grade factors of conformation, finish, and quality. The grade factors are described in subjective terms. Conformation refers to the form or shape of the animals, to the ratio of meat to bone. Finish refers to the amount, color, and quality of fat within and around the muscle. Quality, to the extent it can be determined by visual inspection, refers to the tenderness, juiciness, and palatability of the meat *(6)*. It is recognized that the balancing of the three grade factors in arriving at a composite carcass grade presents a difficult problem and that research to provide information concerning the importance of these grade factors is needed *(7)*.

There appears to be in the literature no investigation of a consumer household panel's preferences for beef from Hereford and Holstein carcasses. The present study investigates such preferences. On the basis of carcass grade, Hereford steers tended to grade higher than Holsteins. For Herefords the Federal grader's evaluation of the three grade factors was similar to the composite carcass grade. For Holsteins, however, the conformation grade was much lower and the finish grade somewhat lower than the quality grade. The composite carcass grade, consequently, was lower than the quality grade.

Since past studies indicated that preferences are influenced by grade *(2, 4, 5)*, the present study presents visual and eating preferences of a consumer household panel for beef from animals of different breed and these preferences are analyzed on the basis both of carcass grade groupings and of quality grade groupings. In addition, ratings were obtained for the eating preferences and these also were analyzed on the basis of the two grade groupings. Simone, Carroll, and Rollins *(8)* conducted concurrently an eating evaluation study by a laboratory panel.

MATERIALS AND METHODS

Animals. Eight pairs of Hereford and Holstein steers from the University of California herds were made available for this preference study. Information concerning history, feedlot performance, and carcass analysis of these animals is summarized by Simone Carroll, and Rollins *(8)*. Pertinent to a consumer preference study is the fact that steers of controlled history were used. The steers were above average in quality; they differed primarily in breed and grade. Since Herefords have a tendency to fatten more rapidly and to mature sooner than Holsteins, the Hereford steers selected for this study were about 6 months younger than the Holsteins.

Two steers from each breed were slaughtered weekly for 4 consecutive weeks. At time of slaughter the 8 Hereford steers were assigned carcass grades by a Federal inspector of 1 *prime*, 6 *choice*, and 1 *good;* their quality grades were the same. For Holsteins, grades based on quality tended to be higher than those based on conformation and, to a lesser extent, on finish. Consequently, the carcass grades of 1 *choice* and 7 *good* assigned the Holstein steers were lower than their quality grades of 1 *prime*, 5 *choice*, and 2 *good*.

The carcasses were aged 8 days at 34° F. After the aging period short loin and sirloin wholesale cuts from both sides of the carcasses were subdivided into steaks approximately one inch thick. Cutting of all wholesale cuts was done by the same person and procedures were standardized so that the first steaks from the short loin and sirloin cuts were at the same anatomical position for both sides of each carcass. On the day of cutting the steaks were paired, trimmed, coded, and distributed. Steaks from Hereford and Holstein carcasses were paired according to cutting sequence and came from the same relative location in their respective wholesale cuts. Each pair was then trimmed to the extent necessary to eliminate outside fat as a possible grade-recognition factor. For purposes of identification one steak of each pair was tagged with a metal clip; the tagged steak alternately represented the Hereford and Holstein carcass.

Consumer household panel.[b] The panel was selected from households of married students enrolled at the University of California, Davis campus, during the Fall semester, 1958. It was composed of husbands and wives of each household and represented a young age group, the majority being in their early and middle twenties. A total of 494 households participated in the preference study during September and October, 1958. Panel members were unaware that any difference between the 2 steaks was either one of breed or of breed and grade.

A one-page preference sheet was used to record the reactions of each panel member to the paired steaks. On it, visual preferences for over-all quality, marbling, and color, and eating preferences for over-all quality, taste, juiciness, and tenderness were recorded. In addition, each of the 4 eating preferences were scored according to a 6-point scale. Numerical scores of 1 through 6 were assigned to the descriptive terms of *excellent, very good, good, fair, poor,* and *very poor,* respectively; thus, the lower the score the higher the preference rating. Scores for Holstein steaks were assigned a positive value and those for Hereford steaks a negative one. Both steaks were scored by each panel member.

Statistical analysis. Before determining the significance of preferences of panel members, half of the no-preference group was assigned to each of the 2 preference categories. The appropriate value of χ^2 for both preferences and ratings was then calculated in the usual manner *(9)*.

RESULTS AND DISCUSSION

Breed preferences of panel members were analyzed for 2 grade groupings of Hereford and Holstein steers; namely, stamped carcass grade and quality grade. Only 2 of the 8 pairs were from steers of identical grade for the carcass grade grouping, while 6 of the 8 pairs were from fairly homogeneous steers for the quality grade grouping. Consequently, in the

* This report on preferences of a consumer household panel is part of a study undertaken by the Departments of Animal Husbandry, Food Technology, and Home Economics of the University of California at Davis.

[b] Instructions to panel members are described in an earlier study *(3)*.

TABLE 1

Preferences for steaks by wholesale cut, breed, and carcass grade grouping

A. Visual preferences

Carcass grade grouping	No. of responses	Over-all			Marbling			Color		
		Hereford	Holstein	None	Hereford	Holstein	None	Hereford	Holstein	None
Short Loin (%)										
I	110	56	38	6	47	47	6	38	45	17
II	282	50	44	6	48	45	7	30	40	30
III	62	34[1]	61[1]	5[1]	48	42	10	11[2]	61[2]	28[2]
Sirloin (%)										
I	130	44	48	8	32[2]	58[2]	10[2]	48	35	17
II	332	47	40	13	50[2]	35[2]	15[2]	30[2]	46[2]	24[2]
III	72	35	57	8	46	50	4	24[2]	61[2]	15[2]

B. Eating preferences

Grade grouping	No. of responses	Over-all			Taste			Juiciness			Tenderness		
		Hereford	Holstein	None	Hereford	Holstein	None	Hereford	Holstein	None	Hereford	Holstein	None
Short Loin (%)													
I	110	38	52	10	35	54	11	31[1]	55[1]	14[1]	48	30	22
II	282	36[1]	52[1]	12[1]	29[2]	49[2]	22[2]	38	43	19	43	35	22
III	62	52	42	6	36	37	27	69[2]	26[2]	5[2]	44	35	21
Sirloin (%)													
I	130	45	45	10	35	49	16	49	42	9	56[2]	32[2]	12[2]
II	332	52[2]	32[2]	16[2]	44[1]	32[1]	24[1]	41	32	27	55[2]	26[2]	19[2]
III	72	72[2]	24[2]	4[2]	56[1]	30[1]	14[1]	69[2]	18[2]	13[2]	72[2]	14[2]	14[2]

[1] Significant at the .05% level.
[2] Significant at the .01% level.

discussion of preferences based on carcass grade no attempt is made to distinguish between the effects of breed and those of grade. In the discussion of preferences based on quality grade, however, the effects both of breed and of grade are presented.

Breed comparison based on carcass grade grouping. In Table 1 visual and eating preferences of the 988 panel members are summarized by wholesale cut, breed, and carcass grade grouping of Hereford and Holstein steers. Using the designations of Table 1, the steers were paired on the basis of carcass grade into the following 3 groups:

I. 1 pair of steers grading *choice* and 1 pair grading *good;*
II. 5 pairs of Hereford and Holstein steers grading *choice* and *good*, respectively;
III. 1 pair of Hereford and Holstein steers grading *prime* and *good*, respectively.

Thus, information was obtained for paired steaks from steers of identical carcass grade and different breed, and also from paired steaks of different carcass grade and different breed.

The data indicate that, in general, *visual breed preferences* of panel members for over-all quality and for marbling either were not significant at the 5 or 1% levels or were not systematic. When significant color preferences were indicated, they were in favor of Holstein steers. Simone, Carroll, and Rollins *(8)* also reported that the laboratory panel in evaluating the color of ground bottom round muscle found significantly darker color for Holsteins than for Herefords.

The data also indicate that *eating breed preferences*, particularly for over-all quality and for taste, tended to be reversed. For the short loin cut eating preferences, in general, were in favor of Holsteins. Over-all quality and taste preferences were significant for Group II and juiciness preferences for Group I. Significant juiciness preferences were also indicated for Group III but they were in favor of the prime-graded Herefords rather than the good-graded Holsteins. Tenderness preferences were not significant for any group. By comparison, for the sirloin cut eating preferences were in favor of the Herefords. Tenderness preferences were significant for all groups. Over-all quality and taste preferences were significant for Groups II and III, while juiciness preferences were again significant for Group III. The laboratory panel's scores for tenderness and juiciness reported by Simone, Carroll, and Rollins *(8)* were in agreement with those of members of the household panel evaluating steaks from the sirloin cut. No flavor differences were indicated by the laboratory panel.

In Table 2 average differences between Hereford and Holstein ratings for each of the over-all preference categories when grouped by carcass grade give an indication of the degree of preference of panel members for the two breeds. The rating differences for the Hereford and Holstein categories were highly significant. Of the four eating preferences, for Holsteins taste had the highest rating difference, while for Herefords tenderness, with one exception, had the highest. In addition, for the short loin cut the rating difference was higher for taste and lower for tenderness for Holsteins than for Herefords. By comparison, for the sirloin cut the rating difference was higher for tenderness and, to a lesser extent, for juiciness and for over-all quality for Herefords than for Holsteins.

Breed comparison based on quality grade grouping. Visual and eating preferences of panel members are summarized by wholesale cut, breed, and quality grade grouping of steers in Table 3. The steers were paired on the basis of quality grade into the following 3 groups:

A. 1 pair of Hereford and Holstein steers grading low choice and prime, respectively;

TABLE 2

Average differences between Hereford and Holstein ratings grouped by carcass grades

Carcass grade grouping	Over-all preference category	Eating preferences							
		Short loin				Sirloin			
		Over-all	Taste	Juiciness	Tenderness	Over-all	Taste	Juiciness	Tenderness
I	No preference	− .10	− .10	+ .30[1]	− .20	0	+ .23	− .38	− .30
	Hereford	− .76[2]	− .80[2]	− .73[2]	− .83[2]	−1.08[2]	− 98[2]	− .67[2]	−1.18[2]
	Holstein	+ .91[2]	+1.13[2]	+1.10[2]	+ .55[2]	+1.00[2]	+1.05[2]	+ .62[2]	+ .42[1]
II	No preference	− .03	+ .11	− .17	− .09	− .04	+ .09	− .06	− .18
	Hereford	− .86[2]	− .63[1]	− .67[2]	− .90[2]	−1.05[2]	− .85[2]	− .84[2]	−1.24[2]
	Holstein	+ .80[2]	+ .91[2]	+ .73[1]	+ .53[1]	+ .70[2]	+ .77[2]	+ .39[2]	+ .52[2]
III	No preference	0	+ .25	− .75	− .50	+ .33	+ .33	0	0
	Hereford	− .03[3]	− .65[2]	−1.00[2]	− .81[2]	−1.23[2]	− .98[2]	−1.00[2]	−1.32[2]
	Holstein	+ .88[2]	+1.15[2]	+ .26	+ .53[1]	+ .52[2]	+ .94[2]	− .06	− .06

[1] Significant at the .05% level.
[2] Significant at the .01% level.
[3] Significant at the .001% level.

B. 6 pairs of Hereford and Holstein steers, 1 pair grading good and low choice, respectively; 2 pairs grading choice and top good, respectively; 3 pairs grading choice;[c]

C. 1 pair of Hereford and Holstein steers grading prime and low choice, respectively.[d]

When pairs of steers were grouped on a quality rather than a carcass grade basis, the effect of grade as well as breed on preferences was much more pronounced. The data indicate that panel members evaluating steaks from fairly homogeneous pairs of steers quality-wise (Group B) did not have either an over-all visual quality or a marbling breed preference but did have a significant color preference for the darker-color steaks of the Holstein steers. When steaks from steers differing materially quality-wise were paired, panel members indicated an over-all quality preference for the steak from the breed of lower rather than higher quality; these preferences were significant for steaks from the short loin cut.

Panel members evaluating steaks from fairly homogeneous pairs of steers tended to reverse their eating breed preferences for the 2 wholesale cuts, preferring steaks from the short loin cut of Holsteins and those from the sirloin cut of Herefords. It appears likely that this reversal should not be attributed solely to a breed difference. As pointed out earlier, a difference of 6 months existed in the average age of the 2 breeds, Holsteins having an average age of 28 months and Herefords, 22. An earlier preference study of a consumer household panel's preferences for steaks from 18 and 30 month steers *(3)* indicated eating preferences consistently in favor of steaks from the younger steers and much more pronounced for steaks from the sirloin than from the short loin cut.

When steaks from steers which differed materially quality-wise were paired, data indicated that grade as well as breed affected eating preferences. The proportion of panel members indicating an eating prefer-

[c] Visual and eating preferences did not differ materially for the 6 pairs of steers. In addition, carcass composition data supplied by Carroll *(1)* tended to indicate that significant quality variations did not exist between these pairs.

[d] Same pair of steers classified on the basis of carcass grade as Group III.

TABLE 3

Preferences for steaks by wholesale cut, breed, and quality grade grouping

A. Visual preferences

Quality grade grouping	No. of responses	Over-all			Marbling			Color		
		Hereford	Holstein	None	Hereford	Holstein	None	Hereford	Holstein	None
Short Loin (%)										
A	54	67[2]	29[2]	4[2]	63[1]	33[1]	4[1]	44	32	24
B	338	49	45	6	45	47	8	30[1]	43[1]	27[1]
C	62	34[1]	61[1]	5[1]	48	42	10	11[2]	61[2]	28[2]
Sirloin (%)										
A	72	51	42	7	29[2]	61[2]	10[2]	50	29	21
B	390	45	42	13	48	38	14	32[1]	45[1]	23[1]
C	72	35	57	8	46	50	4	24[2]	61[2]	15[2]

B. Eating preferences

Grade grouping	No. of responses	Over-all			Taste			Juiciness			Tenderness		
		Here-ford	Hol-stein	None	Here-ford	Hol-stein	None	Here-ford	Hol-stein	None	Here-ford	Hol-stein	None
Short Loin (%)													
A	54	31	56	13	31	56	13	24[2]	63[2]	13[2]	46	39	14
B	338	38[1]	51[1]	11[1]	31[2]	49[2]	20[2]	38	43	19	44[1]	33[1]	23[1]
C	62	52	42	6	36	37	27	69[2]	26[2]	5[2]	44	35	21
Sirloin (%)													
A	72	43	50	7	28[2]	60[2]	12[2]	46	46	8	57[1]	33[1]	10[1]
B	390	51[2]	33[2]	16[2]	45[1]	32[1]	23[1]	43[1]	33[1]	24[1]	55[2]	27[2]	18[2]
C	72	72[2]	24[2]	4[2]	56[1]	30[1]	14[1]	69[2]	18[2]	13[2]	72[2]	14[2]	14[2]

[1] Significant at the .05% level.
[2] Significant at the .01% level.

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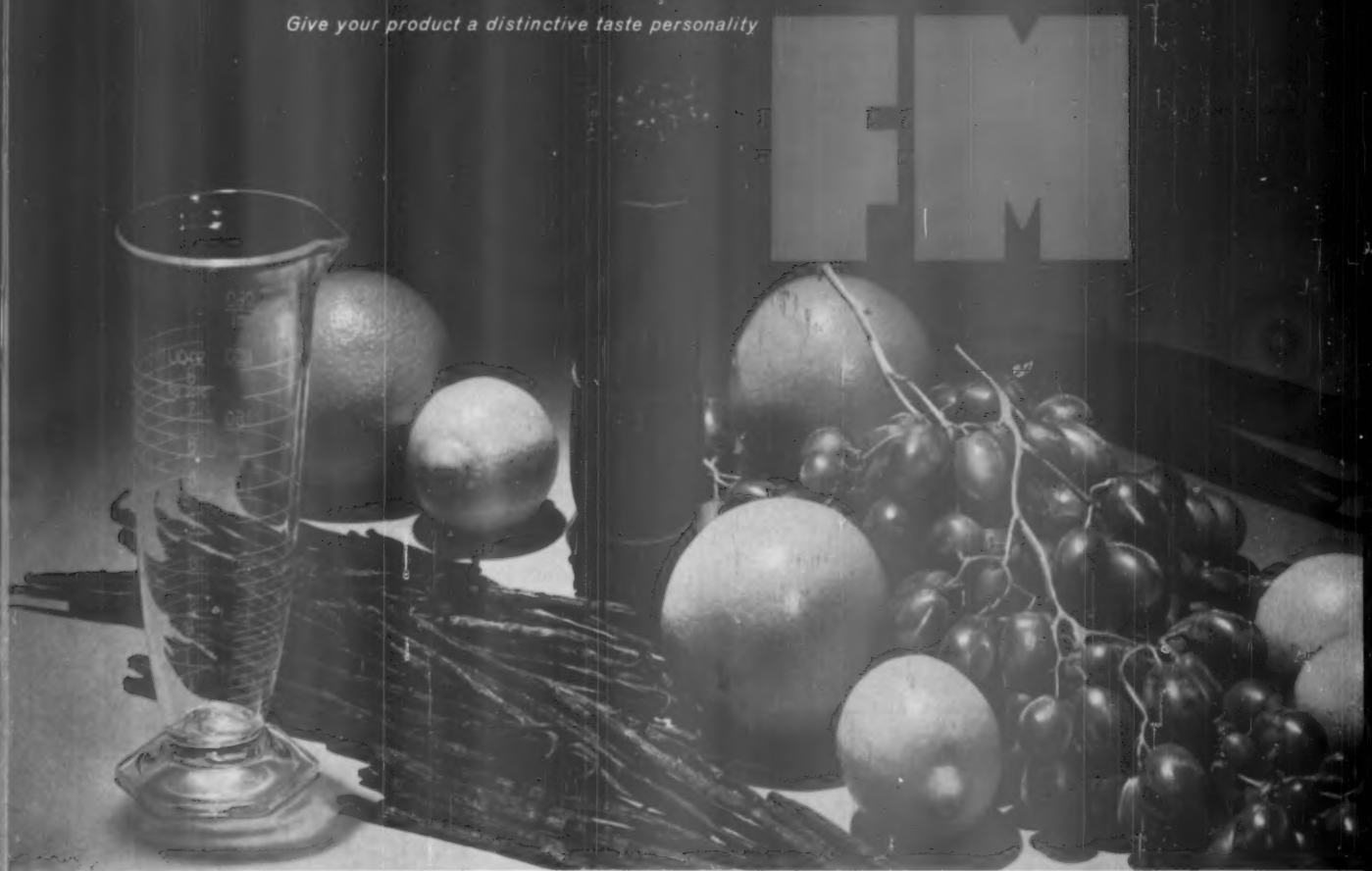

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Protein	9.00 grams	10.50 grams
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Pantothenic Acid	150.0 milligrams worth
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ence for Holsteins tended to be highest when they were paired with Herefords of a lower quality grade than Holsteins (Group A) and lowest when paired with Herefords of a higher quality grade (Group C). The reverse relation tended to be indicated for Herefords. For the short loin cut, panel members evaluating Groups A and C indicated highly significant juiciness preferences for steaks from the steer having the higher quality grade. For the sirloin cut, taste and tenderness preferences of those evaluating Group A were significantly in favor of Holsteins and Herefords, respectively. By comparison, all eating preferences of those evaluating Group C were significantly in favor of Herefords, although the taste preference was not as highly significant as the others.

Average differences between breed ratings for the over-all preference categories grouped by quality grade are summarized in Table 4. As was the case when preference categories were grouped by carcass grade, the rating differences for Herefords and Holsteins grouped by quality grade were highly significant. The difference in the degree of preference indicated for the Hereford and Holstein categories of Groups A and C illustrated the effect of grade on eating preferences; Holstein rating differences of Group A were higher than those of Group C while the reverse relation existed for Herefords.

In Group A for the short loin cut the rating differences were much higher for Holsteins than for Herefords with the exception of tenderness which had the same rating difference for the 2 breeds. The reverse relation was indicated for the sirloin cut; only for the factor of taste was the rating difference higher for Holsteins than for Herefords. Since lack of tenderness was more pronounced for Holsteins in the sirloin than short loin cut, it is not surprising that in Group A for the short loin cut the differences in the degree of preference indicated for Holsteins and Herefords were fairly sizable except for the tenderness factor, whereas for the sirloin cut the differences were not as sizable except for tenderness. It is interesting that in Group C for the short loin cut rating differences were higher for Herefords than for Holsteins except for taste. For the sirloin cut the rating differences for juiciness and tenderness were considerably higher for Herefords than for Holsteins, whereas those for taste indicated the same degree of preference for each breed.

Compared with over-all quality, the tendency in Groups A and C was for the taste factor to have a higher rating difference for Holsteins and for the tenderness factor to have a higher rating difference for Herefords. Consequently, it would appear that the taste factor for Holsteins and the tenderness factor for Herefords may have influenced the ratings both of over-all quality and of the other 2 factors. In addition, from the degree of preference indicated for the over-all quality as well as for the 3 factors it appeared likely that tenderness, when a negative factor, exerted more of a "halo effect" than taste; results from an earlier study evaluating steaks from steers of different age *(3)* indicated a similar tendency.

SUMMARY

Preference evaluations of a consumer household panel for steers differing in breed and grade were obtained. These evaluations were grouped for analysis on the basis of both carcass grade and quality grade. Analysis of the data indicated that preferences were more closely related to quality than to carcass grade.

Visual preferences did not appear to be related to breed except for color, a preference being indicated for the darker-color steaks of the Holstein. Eating preferences were significantly related to breed and grade. The quality grade grouping, however, gave a better indication of the effects both of breed and of grade than did the carcass grade grouping. For the two groupings, eating preferences of panel members tended to be reversed for the wholesale cuts; they were in favor of Holsteins for steaks from the short loin cut and of Herefords for those from the sirloin cut. Average differences between breed ratings for the over-all preference categories indicated that for Herefords the degree of preference was highest for tenderness; for Holsteins it was highest for taste.

Acknowledgments

The author wishes to express sincere appreciation to Mrs. Doreen Simon for her assistance in the preparation and distribution of the steaks and to Mrs. Thelma Kido for her assistance in securing household panel members. Thanks are also due to Mr. Walter Maslan for his assistance in preparing the steaks.

TABLE 4

Average difference between Hereford and Holstein ratings grouped by quality grades

Quality grade grouping	Over-all preference category	Eating preferences							
		Short loin				Sirloin			
		Over-all	Taste	Juiciness	Tenderness	Over-all	Taste	Juiciness	Tenderness
A	No preference	− .14	− .29	+ .43[1]	− .29	0	+ .20	− .60[3]	− .20
	Hereford	− .41[1]	− .35	− .06	− .65[1]	−1.13[3]	− .97[3]	− .81[3]	+1.23[3]
	Holstein	+1.07[3]	+1.17[3]	+1.03[3]	+ .63[1]	+ .97[3]	+1.22[3]	+ .75[3]	+ .31
B	No preference	− .03	+ .13	− .16	− .08	− .03	+ .11	− .08	− .21
	Hereford	− .89[3]	− .73[2]	− .78[3]	− .91[3]	−1.06[3]	− .87[3]	− .86[3]	−1.23[3]
	Holstein	+ .80[3]	+ .94[3]	+ .80[3]	+ .52[1]	+ .77[3]	+ .78[3]	+ .40[3]	+ .54[3]
C	No preference	0	+ .25	− .75	− .50	+ .33	+ .33	0	0
	Hereford	− .93[3]	− .65[3]	−1.00[3]	− .81[3]	−1.23[3]	− .98[3]	−1.00[3]	−1.32[3]
	Holstein	+ .88[3]	+1.15[3]	+ .26	+ .58[1]	+ .52[2]	+ .94[3]	− .06	− .06

[1] Significant at the .05% level.
[2] Significant at the .01% level.
[3] Significant at the .001% level.

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Effect of Storage and of Cooking on Chlortetracycline Residues in Meat[a, b]

Ofelia I. Escanilla, Agnes Frances Carlin and John C. Ayres

Departments of Dairy and Food Industries and Home Economics Research, Iowa State University, Ames, Iowa

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The use of antibiotics in the preservation of meat was reviewed recently by Deatherage *(5)*. Several investigators have determined not only the effectiveness of antibiotics in extending the keeping quality of beef, but also the detectable antibiotic in the raw tissues after storage *(6, 9, 10)*. After 72 hours at 10° C., Goldberg, Weiser, and Deatherage *(6)* detected no Aureomycin [c] residue in raw ground meat to which 2 p.p.m. of the antibiotic had been added. Also Jay, Weiser, and Deatherage *(9)* reported that residues in raw beef rounds, infused with approximately 5 p.p.m. of chlortetracycline (CTC), were nil in almost every case after a holding period of from 3 to 20 days at room temperature.

Although the effectiveness of CTC in extending the storage life of raw meat has been reported, little information exists on the inactivation of the antibiotic with the application of heat. To date, most of the studies on heat inactivation of CTC in flesh foods have been conducted on poultry *(1, 4, 5)* and on fish *(2, 3)*. Poultry and fish are generally dipped in solutions containing antibiotics and these foods are cooked to the well-done stage. However, the antibiotic may be mixed with ground red meats and uniformly distributed at all depths. Also the degree of cooking the red meats receive varies greatly; steaks or ground beef may be consumed when the interior is almost raw. Therefore, it is important to measure the extent of inactivation of CTC in meat cooked to different internal temperatures. Since the opportunity for bacterial contamination is greater in ground meat or in sausage-type meat products than it is in whole carcasses or in meat cuts and because of the ease of adding the antibiotic to ground products, ground beef and frankfurters were chosen for study.

The objectives of this study were (a) to determine the influence of different temperatures encountered during cooking on the residual CTC in fresh meat and in sausage-type smoked meat; and (b) to investigate the effect of storage on residual CTC in sausage-type smoked meat.

EXPERIMENTAL PROCEDURE

Two experiments were conducted to determine the residual CTC in raw and in cooked ground beef. In both experiments, ground meat containing 25% fat was prepared from round

[a] Journal Paper No. J-3511 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 1264.

[b] Presented at the 18th Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 27, 1958.

[c] The trade name of Lederle Laboratories Division, American Cyanamid Company, for the antibiotic chlortetracycline is Aureomycin.

steaks graded "U. S. Choice" that were trimmed of fat and ground with the estimated amount of fat (fat trimmings plus suet). Solutions of different concentrations of CTC were added in the amount of 5 ml. per 100 g. of ground meat so that levels of 1.7, 5.0 or 15.0 μg./g. were obtained. Control samples with no antibiotic were prepared by treating the meat with an equivalent amount of distilled water. After the ground meat was stored at 42 ± 2° F. for approximately 21 hours, patties were prepared and cooked in accordance with usual broiling procedures.

In the first experiment, 60-g. patties (3 x ½ in.) were cooked to the well-done stage. Samples were broiled for 4 minutes on one side, turned, and then cooked for an additional 2 minutes. Two copper-constantin thermocouples were inserted into the approximate center of the patty and during broiling the temperatures were recorded by an 8-point Brown Honeywell Electronik Recording Potentiometer (Model 153 x 60P8-X-31F1). A total of 96 ground meat patties weighing 60 g. each were broiled to the well-done stage: 4 replicates for each of the 3 levels of antibiotic and 8 patties in each replicate (8 patties: 2 controls plus 6 samples containing only 1 level of antibiotic).

In the second experiment, 120-g. patties (3 x ⅞ in.) were boiled in a similar manner, but the cooking times, and hence the final internal temperatures, were varied as follows: (a) 3 minutes on one side plus 1½ minutes on the other side, 108° F., rare; (b) 4 minutes plus 2 minutes, 118° F., medium-rare; (c) 5 minutes plus 3 minutes, 135° F., medium-done; and (d) 6 minutes plus 4 minutes, 159° F., well done. The cooking times for the different degrees of doneness were based upon the general appearance, color, and juiciness of the meat as determined in preliminary studies. Three thermocouples were inserted into the approximate center of the patty and, as before, the temperatures during broiling were recorded on the recording potentiometer. Twelve patties prepared from meat treated with the same level of CTC as well as 2 controls were cooked for each of the above cooking times, but samples that contained 15 μg./g. of CTC were not cooked to the internal temperature of 135° F. (medium-done stage).

The concentration of CTC in the raw meat was determined. For each replicate, 60-g. samples (3 for each treatment level and 1 control without CTC) were tested for antibiotic activity.

Frankfurters with CTC were prepared by an Iowa packing plant. The antibiotic was incorporated in the meat emulsion in amounts of 15, 30 or 45 μg./g. In addition, control samples without CTC were prepared. In order to determine the effect of processing on CTC, samples of the emulsion, not smoked, and some of the frankfurters were frozen. Then these samples were shipped in dry ice to the laboratory and kept frozen until assays were made.

Frankfurters in one-pound packages wrapped in cellophane and packed in a carton were received from the packing plant the day after processing. The samples, 8 packages of the control and 8 packages of each of the treatment levels, were stored under refrigeration (36 ± 2° F.). After storage for 1, 8, 15, 22 or 29 days, 4 packages (1 from each treatment level) were removed for assay. Each package contained 10 frankfurters. Four frankfurters from each package were reserved for determination of CTC in raw samples. Six frankfurters were cooked in accordance with the directions suggested by the manufacturer; i.e., the frankfurters were placed in boiling water, were held in the water for 10 minutes after the heat was turned off. A copper-constantin thermocouple welded inside a 4-inch hypodermic needle was inserted into the approximate center of the frankfurter. Also, a thermocouple was placed in the cooking water. Temperatures were recorded on the recording potentiometer. At the end of the 10-minute holding period, the average internal temperature of the frankfurters was 181° F., which was also the approximate temperature of the water.

Assay procedure. Antibiotic residues were measured by a method modified from the pad plate assay techniques described by Grady and Williams *(7)* and by Broquist and Kohler *(4)*. A spore suspension of *Bacillus cereus* (ATCC 9634) prepared according to the method described by Grove and Randall *(8)* was used to inoculate brain heart infusion agar adjusted to pH 5.5. The samples of meat under test were placed in Mason jars, diluted 1:3 with phosphate buffer (0.1 M KH_2PO_4, pH 4.5) and ground for 30 seconds in Osterizers.[4] Dilutions of standard CTC from 10.0 μg./ml. to 0.05 μg./ml. were prepared in phosphate buffer.

RESULTS AND DISCUSSION

Heat penetration and cooking data. Cooking 60-g. meat patties (3 x ½ in) for 4 minutes on one side and for an additional 2 minutes on the other side resulted in well-done meat patties with an average internal temperature of 201° F. at the end of the cooking period. Loss in weight during cooking of the 60-g. meat patties was approximately 47% of the raw weight (Table 1).

TABLE 1

Average weight losses[1] for meat patties broiled to different internal temperatures

Internal temperature	Cooking time	Degree of cooking	Weight loss
	min.		%
60-g. patties			
201° F.	6.0	well-done	47
120-g. patties			
108° F.	4.5	rare	22
118° F.	6.0	medium-rare	27
135° F.	8.0	medium-done	35
159° F.	10.0	well-done	40

[1] Each average = 48 determinations for 60-g. samples; 36 determinations for 120-g. samples.

The average internal temperatures of the 120-g. meat patties cooked to different degrees of doneness are shown in Table 1. Weight losses during cooking of 120-g. patties increased from 22 to 40% as cooking was continued from the rare to the well-done stage. However, the per cent loss in weight in the 120-g. samples was smaller than that observed in the 60-g. samples

[4] John Oster Manufacturing Co., Racine, Wisconsin.

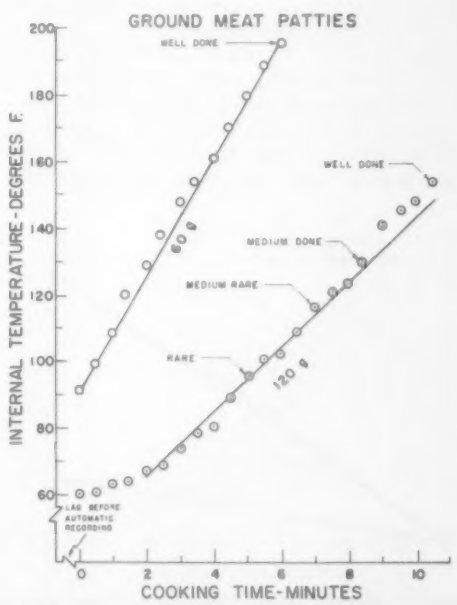

Figure 1. Heat penetration in meat patties.

when both were cooked to the well-done stage. Heat penetration curves plotted for 60-g. and for 120-g. patties (Figure 1) illustrate the more rapid rise in internal temperature for the thinner 60-g. samples.

Residues of CTC in ground meat. When tests were made to determine the immediate loss of CTC before storage, most of the antibiotic was recovered. For example, in one experiment wherein raw ground meat was treated with 5 μg. CTC/g. of beef, 92% of the amount added was assayed. Microbiological assay of antibiotic-treated ground meat samples made after storage of the raw meat (about 28 hours at 42 ± 2° F.) or after cooking indicated that, in either the raw or the cooked meat, residues of CTC were a linear function of the initial concentration. Residues of CTC detected in the raw meat were approximately 66% of the amount of CTC added originally to the ground meat. Data plotted in Figures 2 and 3 indicate that although the residues per unit weight increase with larger concentrations of added CTC, the residual antibiotic in the cooked samples represents a comparable fraction of that in the raw samples regardless of the treatment level used.

Analysis of variance showed a significant effect of treatment level on the residual CTC in the raw meat. In the first experiment in which the ground meat was cooked in the form of 60-g. meat patties, the residual CTC detected in the raw meat after storage (28 hours at 42 ± 2° F.) averaged 65, 62 and 68% of the antibiotic that was added in amounts of 1.7, 5 and 15 μg./g., respectively. In the second experiment, in which ground meat was cooked in the form of 120-g. patties, residual CTC detected in the raw meat treated with 5 μg./g. was 92%. However, the amounts of CTC in the raw meat at the other 2 levels did not differ appreciably from the concentrations found in the first experiment. At the 1.7 μg./g. level, 70% of the antibiotic was detected in the samples, and at the 15 μg./g. level, 65% was detected.

It may be seen in Figure 2 that average residues of CTC in the cooked 60-g. patties were approximately 24% of the amount originally present. However, during cooking, the weight of the 60-g. patties was reduced to approximately 32 g. or 53% of the raw weight. Hence, when corrected for weight loss, the residual CTC represented approximately 12% of the amount present in the raw sample.

The effect of cooking to different final internal temperatures on residual CTC in 120-g. ground meat patties is shown in Figure 3. It is evident from the slopes of the lines corresponding to internal temperatures of 108°, 118°, 135° and 159° F. that residues of CTC decreased with increasing temperatures. This relationship is more clearly illustrated in Figure 4 which indicates that residual CTC in the cooked meat is a logarithmic function of the final internal temperature. Heating to temperatures that usually prevail during broiling reduced, but did not completely inactivate, the antibiotic present in the meat.

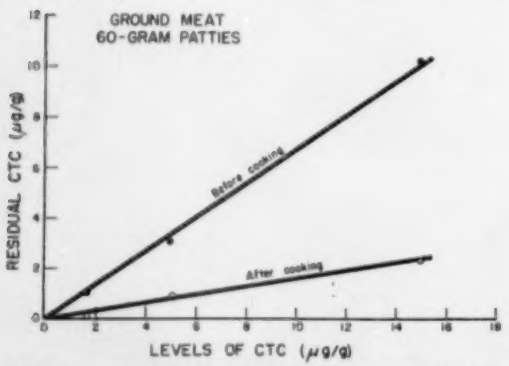

Figure 2. Residual chlortetracycline in ground meat before and after cooking to the well-done stage.

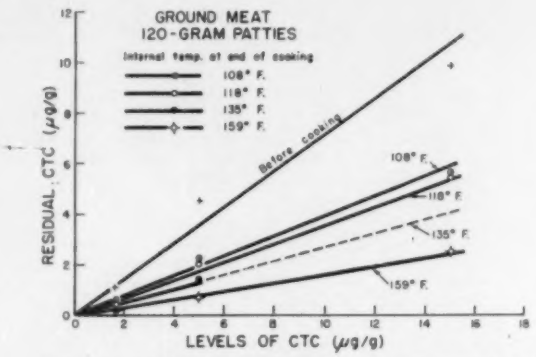

Figure 3. Residual chlortetracycline in ground meat before and after cooking to different internal temperatures.

The residual CTC detected in 120-g. and 60-g. patties is summarized in Table 2. After correcting for weight loss, the average residues of CTC in cooked 120-g. patties were about 40% at 108° F., 34% at 118° F., 19% at 135° F. and 13% at 159° F.

Reports by several investigators on the effect of cooking on CTC in poultry have indicated that Aureomycin present in poultry tissue was completely inactivated *(1, 4)*. Results reported in the present in-

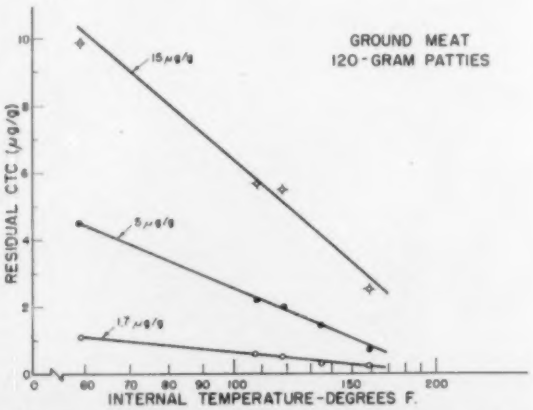

Figure 4. Relation of residual chlortetracycline to internal temperature in broiled ground meat patties.

vestigation on residues found in ground meat do not necessarily contradict those reported for poultry since the conditions of application of antibiotics in red meats are completely different from those used in poultry. The antibiotic is on or near the surface of poultry where it is exposed to the highest heat, while in meat patties or frankfurters it is uniformly distributed at all depths. Also, the internal temperatures attained in cooking beef are comparatively lower than those ordinarily used in cooking poultry.

Extrapolation of the curves in Figure 4 would reveal that at treatment levels of 1.7 or 5.0 μg./g., a temperature of about 200° F. might be expected to reduce the residues to undetectable amounts. Cooking to the extrapolated temperature of approximately 230° F. for the 15 μg./g. level would not be practical as preliminary studies showed that broiling 120-g. patties for longer periods of time than 14–15 minutes and to internal temperatures of 205°–210° F. resulted in less acceptable products because of excessive cooking losses and charring. However, even in the case of the 60-g. patties in which the final average temperature was 201° F., the antibiotic was present in detectable amounts in the cooked meat (Table 2).

Residues in frankfurters. Data obtained on the effect of commercial processing of frankfurters on the concentration of CTC indicated that a large percentage of the CTC added to the emulsion was inactivated during processing. After about 3 hours in the smokehouse, during which time the internal temperature was raised to 150° F., and after cooking in a Jordan Cooker (150° F.), only about 15% of the antibiotic added to the emulsion was detected in the frankfurters (Table 3). These results indicated that if CTC is to be effective in prolonging the storage life of frankfurters, it would be necessary to use antibiotic levels which would be high enough to permit 85% destruction of the antibiotic during processing.

TABLE 2

Residual CTC in ground meat patties broiled to different internal temperatures

Treatment levels (μg./g.)	Residual CTC (μg./g.)				
	120-gram [1]				60-gram [2]
	108° F.	118° F.	135° F.	159° F.	201° F.
1.7	0.6	0.5	0.3	0.3	0.2
5.0	2.2	2.0	1.5	0.7	1.0
15.0	5.6	5.5	....	2.5	2.3

[1] Average of 24 determinations, for each antibiotic level at each internal temperature.
[2] Average of 48 determinations, for each antibiotic level at each internal temperature.

TABLE 3

Effect of commercial processing on CTC concentration in frankfurters

Treatment levels	CTC[1] before processing	CTC[2] after processing	
μg./g.	μg./g.	μg./g.	%
15	14.7	....	....
30	28.1	4.3	15.2
45	41.5	6.6	15.8

[1] Average of 14 determinations, for each level of antibiotic.
[2] Average of 12 determinations, for each level of antibiotic.

An examination of the data plotted in Figure 5 reveals that CTC residues in raw frankfurters decreased as the amount of CTC added to the emulsion was reduced from 45 to 15 μg./g. The plotted data indicated that the concentration of CTC in the frankfurters was not affected by storage at 36 ± 2° F. (Figure 5). Analysis of variance confirmed the observation that under the conditions used in this study, storage had no significant effect on residual CTC regardless of treatment level.

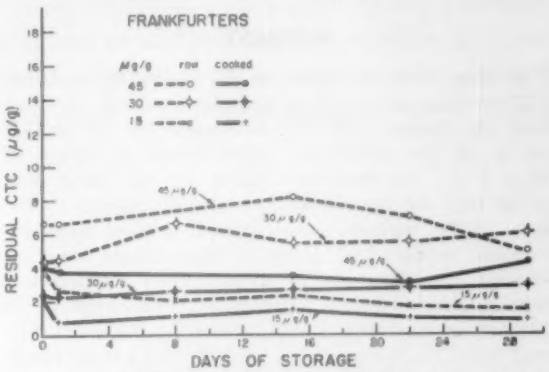

Figure 5. Residual chlortetracycline in frankfurters during storage and after cooking.

The heat penetration curve for frankfurters is shown in Figure 6. After 10 minutes holding in hot water, the average internal temperature attained at the center of the frankfurters was 181° F. Since storage was shown to have no significant effect, data were combined for the residual CTC in cooked frankfurters at each treatment level. Statistical analysis of the data obtained on the cooked frankfurters revealed

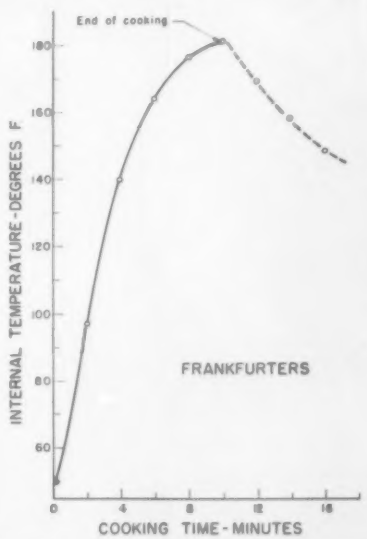

Figure 6. Heat penetration in frankfurters.

a highly significant effect for treatment level but no significant effect for storage. Cooking according to the commercially prescribed procedure reduced the CTC in the cooked frankfurters to about 50% of the concentration detected in the raw frankfurters.

Under the conditions used in this experiment, processing, storage and cooking resulted in a total inactivation of 85–95% of the CTC added to the meat emulsion. Although results obtained showed that a large percentage of the CTC was inactivated, it should be emphasized that 80–85% of the antibiotic inactivation occurred during processing in the plant.

SUMMARY

Studies were conducted to determine the residual CTC in meat after storage and after cooking. Ground beef was treated with CTC to contain 1.7, 5.0 or 15.0 μg./g. of the antibiotic. After about 28 hours at 42 ± 2° F., the residual CTC in the raw meat was about 66% of the antibiotic originally added to the meat. CTC residues in the cooked ground meat decreased as the final internal temperature was increased. Residues of CTC at any given temperature were a direct function of the initial concentration in the raw ground meat. Also the results indicated that residual CTC in cooked meat patties was a logarithmic function of the internal temperature at the end of cooking.

In frankfurters, the greatest loss of CTC occurred during the commercial processing in the packing plant. Only about 15% of the CTC added in the meat emulsion (15, 30 or 45 μg./g.) was detected in the raw frankfurters. After cooking the frankfurters in boiling water to 181° F., the CTC concentration was reduced approximately 50%. Thus processing and cooking resulted in a total inactivation of 85–95% of the CTC in frankfurters.

In this study, regardless of treatment level of CTC or the temperature attained during cooking, the antibiotic in the meat was not reduced to undetectable amounts.

Acknowledgment

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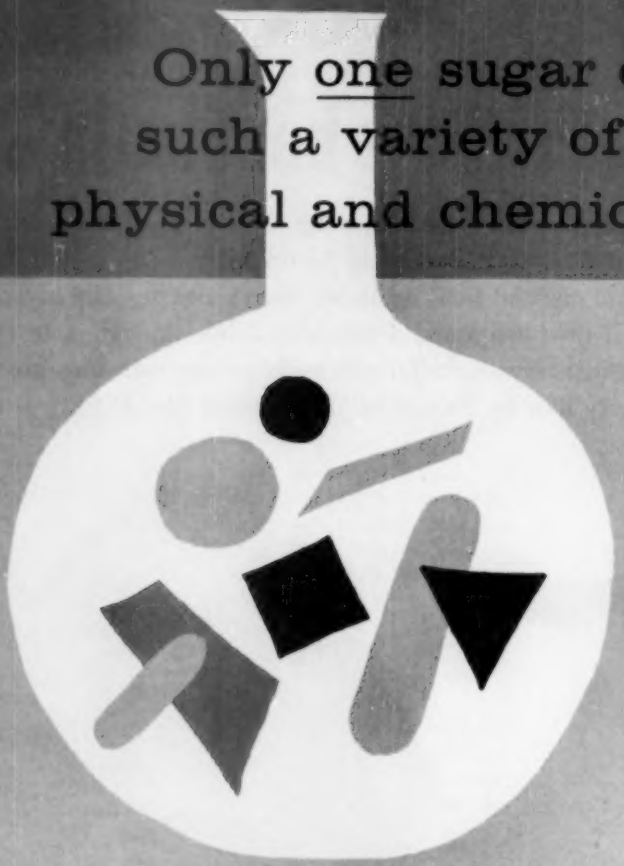

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The Effect of Forty-three Years of Storage On Strawberry Preserves[a]

Gideon E. Livingston[b] and Chee Teck Tan

Department of Food Technology, University of Massachusetts, Amherst, Massachusetts

(Manuscript received March 18, 1959)

MOST OF THE INVESTIGATORS who have concerned themselves with the problem of color change in strawberry preserve have stressed the rapidity with which chemical reactions inducing browning (i.e., anthocyanin degradation, carbohydrate-organic acid reactions, etc.) proceed. Several months of storage at room temperature are usually sufficient to produce a definite off color, and the associated ultraviolet absorption caused by the presence of furfuraldehyde and other carbonyl products of carbohydrate breakdown. For these reasons, we welcomed the opportunity to examine a sample of home-made strawberry preserve packed in 1915 by a lady in Sutton, Massachusetts, and stored in a dry cellar during the intervening years.

EXPERIMENTAL

The sample was packed in a shallow Atlas jelly glass, measuring 3 3/16" O.D. at the top, 2 1/8" O.D. at the bottom and 2 3/4" in height (Figure 1). The closure was slightly corroded on the outside and extremely corroded along the inside rim (so much so that the lid was tightly held to the jar), but free of corrosion on the rest of the inside surface. The contents were covered by a layer of wax whose surface exhibited a corrugated appearance. The preserve itself was very dark brown in color, and composed of lumps of fruit and gel in a medium of dark brown syrup.

Because the lid of the jar bulged out, apparently due to internal gas pressure, a sample of the headspace gas was drawn with a syringe and analyzed using a Perkin-Elmer Model 154B Vapor Fractometer. It was found to have the same composition as air, indicating that gas produced in storage must have diffused out under the closure.

Sugars were extracted with hot C_2H_5OH, the latter being evaporated and the residue dissolved in water. The aqueous solution was clarified with neutral lead acetate, the excess lead being precipitated by $Na_2C_2O_4$. The solution was filtered, made to volume and analyzed for glucose, fructose, and sucrose by the Luff-Shoorl modification of the Kolthoff-Kruisheer method *(1)*. For the determination of anthocyanin pigment (pelargonidin-3-monoglucoside) the method of Sondheimer and Kertesz *(5)* was used. Ultraviolet absorption was measured with a Beckman DU Spectrophotometer on a clear extract obtained in the anthocyanin determination, and calculated as mg % of 5-hydroxymethyl-2-furaldehyde *(2)*. Total acidity, moisture, ash and alkalinity of ash were determined by standard A.O.A.C. procedures *(4)*. A Beckman Model G pH meter was used to determine pH, and an Abbe type refractometer was employed to obtain the refractive index, while viscosity was measured with a Brookfield Synchro-Lectric Viscometer equipped with a No. 1 spindle and operated at 20 r.p.m. Color was measured in two ways (a) C.I.E. chromaticity coordinates were calculated by the ten point selected ordinate method from spectral reflectance measurements obtained with the Beckman DU Spectrophotometer, and (b) a Gardner Color Difference meter was used to find the $\tan^{-1} a_L/b_L$ which has been shown by the authors to constitute the most satisfactory measurement of color quality in strawberry preserves *(3)*.

For purposes of comparison, identical analyses were conducted on (a) composite sample of 4 commercially packed jars of strawberry preserves of different brands, purchased in a local market just prior to the analyses, and (b) a sample of strawberry preserves prepared by the open kettle method, processed after packing for 30 minutes at 240° F., (to accelerate discoloration) and kept in an incubator at 100° F. for 2 years prior to the analysis.

RESULTS AND DISCUSSION

The data provide the basis for some interesting observations on the extent to which various chemical changes known to be taking place during the storage of preserves, will proceed over a prolonged time span. For example, the inversion of the sucrose in storage, which is evident from an inspection of data on the fresh and 2-year old sample, is found not to go to completion over the 43-year period. Degradation of the monosaccharides continues, however, as indicated by the very high ultraviolet absorption, and reduced total sugar content.

The anthocyanin pigment is totally lost within the initial months of storage and the color of the preserve is due entirely to end products of the carbohydrate and pigment degradations. The total acid content continues to increase, presumably due to the formation of acidic end products, but the buffer system present maintains a nearly identical pH.

Moisture loss due to evaporation during the prolonged storage is obvious, since the preserve could not very well have had an initial total solids content of

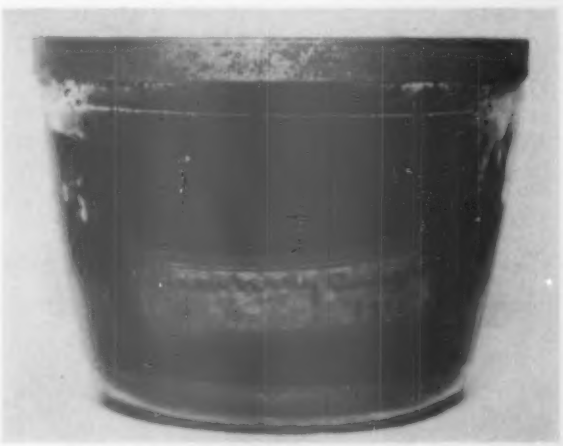

Figure 1. Sample of 43 year-old strawberry preserve.

[a] Contribution No. 1185 University of Massachusetts, College of Agriculture Experiment Station.

[b] Present address Continental Baking Co., Rye, N. Y.

TABLE 1

Results of physical and chemical determinations carried out on fresh, 2 year-old and 43 year-old samples of strewberry preserves

Determination	Sample					
	Fresh		2 Year-old		43 Year-old	
	Wet basis	Dry basis	Wet basis	Dry basis	Wet basis	Dry basis
Glucose (%)	16.4	22.6	31.5	46.0	34.4	44.0
Fructose (%)	17.0	23.4	28.6	41.7	29.7	38.0
Sucrose (%)	34.3	47.2	4.9	7.2	4.6	5.9
Total Sugar (%)	67.7	93.2	65.0	94.9	68.7	88.0
Moisture (%)	27.4		31.5		21.9	
Soluble solids (%)	68.8	94.8	67.7	98.8	76.7	98.2
Total Solids (%)	72.6		68.5		78.1	
Pelargonidin-3-monoglucoside (mg. %)	4.7	6.5	0	0	0	0
Ultraviolet Absorption (as mg. % HMF)	29	32	396	578	930	1191
pH	3.10		3.15		3.10	
Total acid (as % citric acid)	0.56	0.77	0.76	1.11	0.89	1.14
Ash (%)	0.18	0.25	0.19	0.28	0.37	0.47
Alkalinity of ash (ml. 0.1 N HCl)	3.5		0.6		6.1	
Viscosity (centipoise)	37		64		320	
C.I.E. % Y	16.21		4.84		2.91	
x	0.652		0.501		0.473	
y	0.331		0.362		0.378	
$\tan^{-1} a_L/b_L$	61.9		−8.91		−46.9	

78% without undue crystallization. The higher solids content accounts in part at least, for the increased viscosity.

From the standpoint of color, the 2-year-old and the 43-year-old preserve were totally unacceptable, but the older preserve was both darker (−1.93%Y) and less red ($-37.99 \tan^{-1} a_L/b_L$) than the 2-year-old preserve. While the 2-year-old preserve had a bitter and objectionable taste, the 43-year-old sample had merely a very caramelized taste.

In the light of these data, the practice of using short term high temperature storage (at 100° F.) to simulate the chemical changes occurring in preserves over extended storage at room temperature seems justified, although flavor changes which occur under the accelerated conditions might not parallel those taking place over a longer time at lower temperatures.

Acknowledgment

The authors wish to express their appreciation to Professor Kirby M. Hayes of this Department for bringing the 43-year-old preserve sample to their attention.

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Light Destruction of Riboflavin in Partially-baked Rolls[a]

Lois Carter Stephens and Marian Faulkner Chastain

School of Home Economics, Alabama Polytechnic Institute, Auburn, Alabama

(Manuscript received April 11, 1959)

THE ENRICHMENT PROGRAM of recent years has made bread an important contributor to the total intake of B vitamins. That riboflavin is susceptible to destruction by light has been well established by a number of workers who have investigated the phenomenon in bread and in partially-baked (Brown'n Serve) rolls. It has been shown *(3)* that loss of riboflavin in loaf bread is negligible, presumably due, at least in part, to protection from light by the crust. Loy, Haggerty, and Combs *(2)* showed, however, that loss of the vitamin occurs in partially baked rolls which do not have the protective effect of the crust. Losses occurred in riboflavin content of the partially baked rolls both unwrapped and wrapped in clear cellophane when the rolls were exposed to either artificial light or sunlight. Birdsall and Teply *(1)* wrapped rolls in waxed paper and in aluminum foil and exposed them to light. As might be expected, less riboflavin loss occurred in the foil-wrapped rolls. Those wrapped in waxed paper did not lose as much of the vitamin as did the controls.

Use of aluminum foil as a wrapping material might be objectionable to the baker because of increased cost, and possibly to the consumer since the packaged product would not be visible. The investigation here reported was undertaken to evaluate other protective wrapping materials such as colored cellophane, which would not prevent the consumer from viewing the product before purchase. Yellow or amber colored cellophane wrapping would not give the product a color too unlike the natural. The usefulness of amber bottles in protecting chemicals from light destruction is well known. Stamburg and Theophilus *(5)* have shown that light destruction of riboflavin in milk is inhibited by the use of amber bottles.

EXPERIMENTAL PROCEDURES

Twelve-roll packs of partially-baked rolls were obtained as they came off the "line" at a local bakery. Four packs of rolls were wrapped in the bakery's clear cellophane. Three packs were wrapped in DuPont 300 MSC Amber (yellow) cellophane and three in DuPont 300 MSC Tango (orange) cellophane.[b] During transport to the laboratory all packages were carefully protected from light. The riboflavin content of one pack of rolls was determined immediately upon arrival at the laboratory.

Nine packages of rolls (3 in each of the 3 experimental wraps) were exposed at room temperature to 60 foot-candles of light for 1, 2, or 3 eight-hour periods simulating the 8 hours of light in 1, 2, or 3 days on the grocery store shelf. The light intensity as well as the number of periods of light exposure simulated store conditions. Sixty foot-candles was found to be the average intensity of light striking rolls in 5 local stores.

For analysis the 12-roll units, broken into individual rolls, were first dried in an electric oven for four hours at 50°–60° C., and then were dried at room temperature for 12 hours. Loy, Hagerty, and Combs *(2)* used a similar procedure and found that no loss of riboflavin occurred during the drying process. The entire 12 rolls were ground in a Waring blender and were stored in brown glass jars under refrigeration until analysis. Three 8-g. samples of ground material from each package of rolls were used for assay. From the solution made from each 8-g. sample were taken two 10-ml. samples for measurement of riboflavin content. The riboflavin analyses were done according to the A.O.A.C. fluorometric method.

RESULTS AND DISCUSSION

The riboflavin content of the rolls before exposure, and after exposure in each of the 3 wrapping materials is shown in Table 1. The slight rise in riboflavin content after the second exposure period cannot be explained. After a considerably longer exposure time (14 days) Loy, Hagerty, and Combs *(2)* observed an increase in riboflavin content which they attributed to the development of visible mold. Mold was not observed in the work here reported. As can be seen in the table, riboflavin content fell again after the third exposure period. However, that of the rolls in the Tango wrap remained above the value observed after one period of exposure.

That protection was offered by the colored cellophanes is apparent. After each exposure-period greater amounts of riboflavin were found in rolls wrapper in colored cellophane than were found in rolls wrapped in clear cellophane. Of the two colored wrapping materials, that which transmitted less light (Tango) offered the greater protection as might be expected.

In terms of per cent loss, the rolls in the clear cellophane lost 16.5% and those in the Amber, 13.2% of their original riboflavin content after three 8-hour exposure periods. The rolls in the Tango wrap, showed a loss of 1.7% after the same time. However,

TABLE 1

Effect of wrapping material and exposure to light on riboflavin content of partially-baked rolls

Exposure period[1]	Riboflavin (mg./100 g.)		
	Clear cellophane	Amber cellophane	Tango cellophane
0	0.478	.....	.....
1	0.390	0.435	0.444
2	0.406	0.459	0.480
3	0.399	0.415	0.470

[1] Each exposure period represents 8 hours exposed to sixty foot-candles of light.

[a] Based on a thesis submitted by Lois Carter to the Graduate Faculty, Alabama Polytechnic Institute, in partial fulfillment of the requirements for the degree of Master of Science in Home Economics.

[b] Colored cellophanes courtesy of E. I. DuPont de Nemours and Company, Wilmington, Delaware.

a greater loss (7.1%) was obtained in Tango-wrapped rolls after just one exposure period. The riboflavin furnished by 3 rolls (average dry weight, 23 g.) would be 0.33 mg. or 20% of the Recommended Daily Allowance *(4)*. After three 8-hour periods of exposure in clear cellophane, the amount of riboflavin furnished would be 0.28 mg. or 17% of the Recommended Daily Allowance. This slight reduction in nutritive value seems to indicate that light destruction of riboflavin in the product investigated is of minor importance.

As noted above, the experimental conditions were designed to simulate local grocery store lighting. Under these conditions, light-destruction of riboflavin in partially baked rolls is not great. Three of the stores in which lighting conditions were checked were small independent markets. The two stores of super market category had light intensities greater than 60 foot-candles. Greater losses or riboflavin might therefore be expected to occur in the latter type store. On the other hand, sales turnover of the product would be greater in the super market, and although intensity of light striking rolls would be greater, the exposure period would be shorter, and total loss might therefore not differ greatly from losses obtained in this investigation.

SUMMARY

The photo-destruction of riboflavin in partially-baked rolls was investigated under simulated grocery store conditions. Colored cellophane wraps were tested for effectiveness in protecting rolls from light. Losses of riboflavin were slight in all cases. Losses were lower in rolls wrapped in Tango (orange color) wrapping than in Amber (yellow) wrapping and were lower in the latter than in clear cellophane.

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A Comparison of the Methods for Applying Acronize* Chlortetracycline to Beef

(Manuscript received April 2, 1959)

M. C. Firman, H. J. Bachmann, F. J. Heyrich, and P. F. Hopper

Food Industry Department, American Cyanamid Company, Princeton, New Jersey

USE OF ANTIBIOTICS has been among the most outstanding methods of food preservation studied in recent years. Tarr *et al. (14)* reported in 1952 the successful preservation of fish and ground beef by using the broad-spectrum antibiotic chlortetracycline. Since then many reports have been published which demonstrate the effectiveness of this antibiotic on a variety of foods *(1, 3, 6, 7, 11, 12, 13, 15, 16, 21, 22)*. Goldberg *et al. (8)*, Weiser *et al. (19, 20)* and Deatherage *(5)* have shown chlortetracycline to be effective in extending the storage time of red meats.

Ayres *(2)* reviewed the microorganisms isolated from the surface of ground beef. Although a large number of different genera of microorganisms contributed to the initial contamination, Ayres found that at the time of spoilage, more than 98% of the flora was comprised of *Achromobacter* and *Pseudomonas*. These findings were corroborated by Kirsch *et al. (10)* in their studies of the bacteriology of refrigerated ground beef. Chlortetracycline has been demonstrated to effectively inhibit *Pseudomonas* and *Achromobacter*. Goldberg *et al. (8)* reported, moreover, that 81 of 92 distinct microorganisms isolated from beef were inhibited by chlortetracycline. A study *(5)* of 300 isolates from chlortetracycline-treated beef showed no organisms preferentially insensitive to the antibiotic. Extensive studies have been conducted on both animals and humans which have conclusively proven the safety of the antibiotic for food use—even for those rare individuals who are allergic to therapeutic doses of the tetracyclines *(18)*. In order to establish tolerated dietary concentrations of the antibiotic in laboratory animals, rats were fed as much as 10,000 p.p.m. chlortetracycline daily for 2 years without deleterious effect. In fact, there was increased longevity and decreased morbidity above the 100 p.p.m. level *(17)*.

While permission to use chlortetracycline in or upon meats has not as yet been granted by the U. S. Government, approval for such use has been given by several foreign countries. The U. S. Food and Drug Administration in April, 1959, established a tolerance of 5 p.p.m. chlortetracycline in or on uncooked vertebrate fish, shucked scallops, and unpeeled shrimp. A tolerance of 7 p.p.m. chlortetracycline in or upon raw poultry was granted in November, 1955. The purpose of this paper is to demonstrate and to compare the effectiveness of various methods and combinations of methods for applying chlortetracycline to beef under commercial conditions.

MATERIALS AND METHODS

Application. Chlortetracycline (CTC) may be applied to beef by several methods *(4)*. The animal may be injected prior to slaughter, whereby the animal's heart and vascular system are used to disperse the antibiotic thoroughly throughout the meat tissue. The dressed sides of beef may be sprayed with CTC and the chill cloths dipped in the spray solution, whereby the antibiotic is distributed over all surfaces of the meat. The finished retail cuts of meat may be sprayed with the antibiotic or wrapped in cellophane impregnated with CTC, whereby the antibiotic is again distributed over the surfaces of the meat.

Injection. Fifty ml. of a solution containing 1.325 g. CTC sulfate (80% as active as CTC hydrochloride) and 1.325 g. glucose, was injected into the jugular vein toward the heart of each animal. The average animal weighed 500 lb., and the concentration of CTC was calculated at 4.6 p.p.m., based on animal weight. The actual amount attained in the tissues was 0.80 to 0.86 p.p.m. CTC.

Spraying and clothing sides. Each side was sprayed with 125 ml. of a solution containing 100 p.p.m. CTC, 100 p.p.m. citric acid and 800 p.p.m. sodium chloride. Chill cloths were dipped in the same solution prior to application. Non-sprayed sides of beef were covered with chill cloths dipped in 15 to 20% brine.

Spraying retail cuts. Cut steaks were sprayed with a solution containing 100 p.p.m. CTC.

Wrapping retail cuts. Cut steak and ground meat samples were wrapped in cellophane impregnated with CTC.

Packaging. The plain cellophane film used for packaging was Olin Mathieson OF-16. The outside of it was coated with nitrocellulose while the side next to the meat was uncoated so that it would be wet and permeable to oxygen. In the case of antibiotic-treated film, the base sheet was impregnated with CTC so as to give a film assaying 150 γ CTC/g. or 8 to 10 mg./sq. meter by microbiological assay. Trays for ground meat samples were No. 1, Foodtainers, 5″ x 5″ x 1″, Diamond Match Company. Backing boards for steaks were Rodeo Prepackaging Boards, 5″ x 7″, Sutherland Paper Company.

Samples. Individual carcasses were sampled immediately after slaughter and again after hanging 48 hours in a room at 38° to 42° F. Samples were obtained by cutting a 50-g. section from the distal end of the hanging tenderloin, the ventral side of the neck, and the rump portion of the round of each carcass. These samples were then placed in polyethylene bags, frozen by dry ice and shipped to the laboratory for CTC assays and microbial counts.

Individual sides from each treated and untreated carcass were divided so that 10 steaks and 10 one-pound samples of ground meat were available for packaging. Those samples from the left side were packaged in cellophane impregnated with CTC and those from the right side in plain cellophane. All of these packaged samples were stored in a room at 42° F. for various intervals. Two steak and 2 ground meat packages from each side were opened and examined organoleptically for color, appearance, and odor, after which they were closed and, together with the other samples, placed in polyethylene bags, frozen by dry ice and shipped to the laboratory for microbial counts. CTC assays were performed on samples 3 days after packaging.

* The trademark of American Cyanamid Company for the food grade of chlortetracycline is Aeronize.

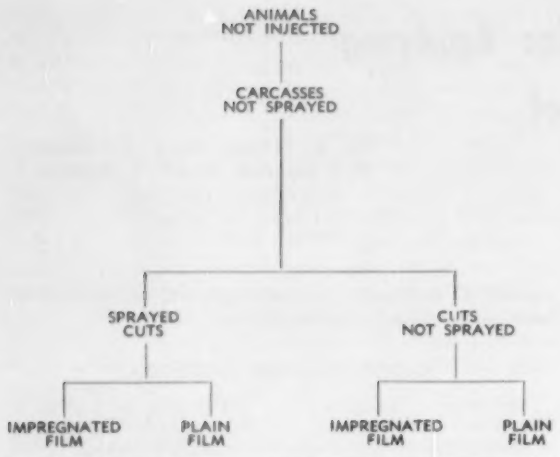

Figure 1. Outline of the "in plant" experiment.

Analytical methods. Microbial counts were performed according to methods reported by Kohler *et al. (13)*. A modified Food and Drug Administration cylinder plate assay method *(9)* was employed to determine the CTC content of samples. The packaged samples were examined each day for color, appearance and odor.

Procedure. Eight animals were injected and 10 held as controls. After 4 hours the animals were slaughtered and dressed. Carcass samples were removed from each side. The sides of 4 injected and 4 non-injected animals were sprayed and clothed with chill cloths dipped in the CTC spray solution. The remaining sides were clothed with chill cloths dipped in brine. The sides were then held in a room at 38° to 42° F. for further processing. After 2 days of storage, the experiment was divided into two separate phases to simulate "in plant" and "in store" retail cutting and packaging.

"In plant" phase. Two of the carcasses which were neither injected nor sprayed were used for the "in plant" test. Ten steak packages were prepared from each side. Those from one pair of sides were packaged with no further treatment. Samples from the other pair of sides were sprayed as indicated and then packaged. In each case the samples from the left side were wrapped in impregnated cellophane and those from the right in plain film.

The packages were placed loosely in cardboard boxes and were trucked 200 miles with 10 stops en route, at which times the truck was opened to simulate delivery to a store after previous unloadings. Temperature of the truck when first opened for loading was 39° F.; after loading it was 51° F. At the first of 10 stops it was 45° F. and at the 10th stop 38° F. The outside temperature was 97° F. at the first stop and 86° F. at the last stop. The individual packages stood the trip quite well and were not distorted. After arrival they were stored in a room at 38° to 42° F. to simulate store handling conditions and sampled as indicated. CTC assays were performed on the samples 3 days after packaging so as to allow the treated film to come into equilibrium with the meat. The outline for the experiment is given in Figure 1 and the results in Table 1. The abbreviation "CTC" will be used throughout the tables for chlortetracycline.

"In store" phase. The "in store" packaging phase of the experiment was performed on the balance of the carcasses. At the end of the 48-hour chill period, the carcasses were again sampled at the neck, tenderloin and round. The chill cloths were removed and the sides trucked 200 miles, as described before. The sides were then held in a room at 38° to 42° F. until cut-up time. On the 3rd day after slaughter one complete set (8 sides) was cut up and packaged. At this time the remaining sides were covered with polyethylene to retard dehydration. On the 5th day the film was removed. On the 6th day after slaughter, one complete set of carcasses (8 sides) was trucked to a store, cut up, packaged and returned for storage. On the 7th day, 2 complete sets (16 sides) were processed in the same manner. In each case 10 steaks and meat for 10 ground meat samples were taken from each side. The samples from the left side were wrapped in CTC-impregnated film and those from the right side in plain film. The methods of CTC application are shown in Figure 2. Results of this phase of the experiment are shown in Tables 2–5.

RESULTS AND DISCUSSION

Chlortetracycline assays and microbial counts.

A. "In plant" experiment. The results are shown in Table 1.

The following observations can be made from the data in Table 1. Film impregnated with chlortetracycline is effective in retarding spoilage of steaks—when microbial counts of treated samples are com-

TABLE 1

Chlortetracycline (CTC) assays and microbial counts of steak treated by CTC spray solution and CTC-impregnated film and stored at 40° F.

Treatment		CTC γ/g. meat[1] (3 days after packaging)	Microorganisms x 10^6/g. meat[1] Days after packaging				
Spray	Film		0	3	5	7	9
None	Plain	0	0.01	0.11	31	70	213
None	CTC	0.17	0.02	0.01	1.7	45	61
CTC	Plain	0.50	0.01	0.01	0.1	0.04	0.3
CTC	CTC	0.47	0.01	0.01	0.02	0.2	0.3

[1] Averages of 2 packages each.

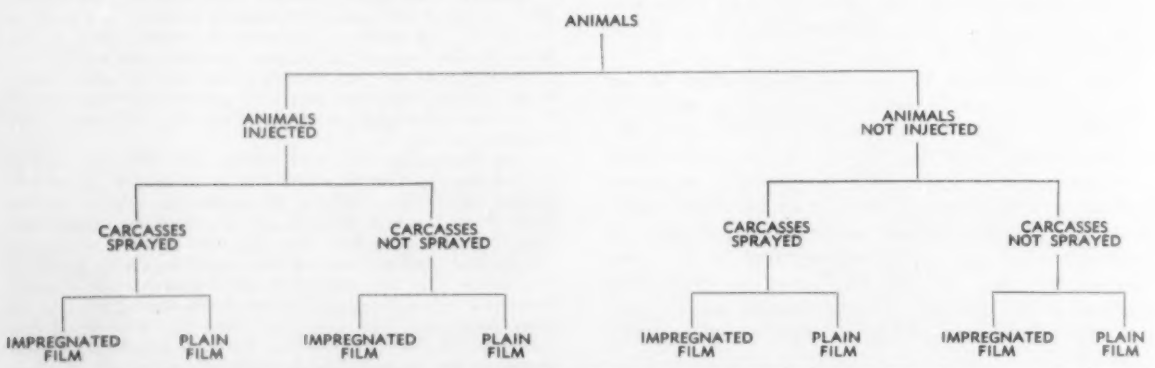

Figure 2. Outline of the "in store" experiment.

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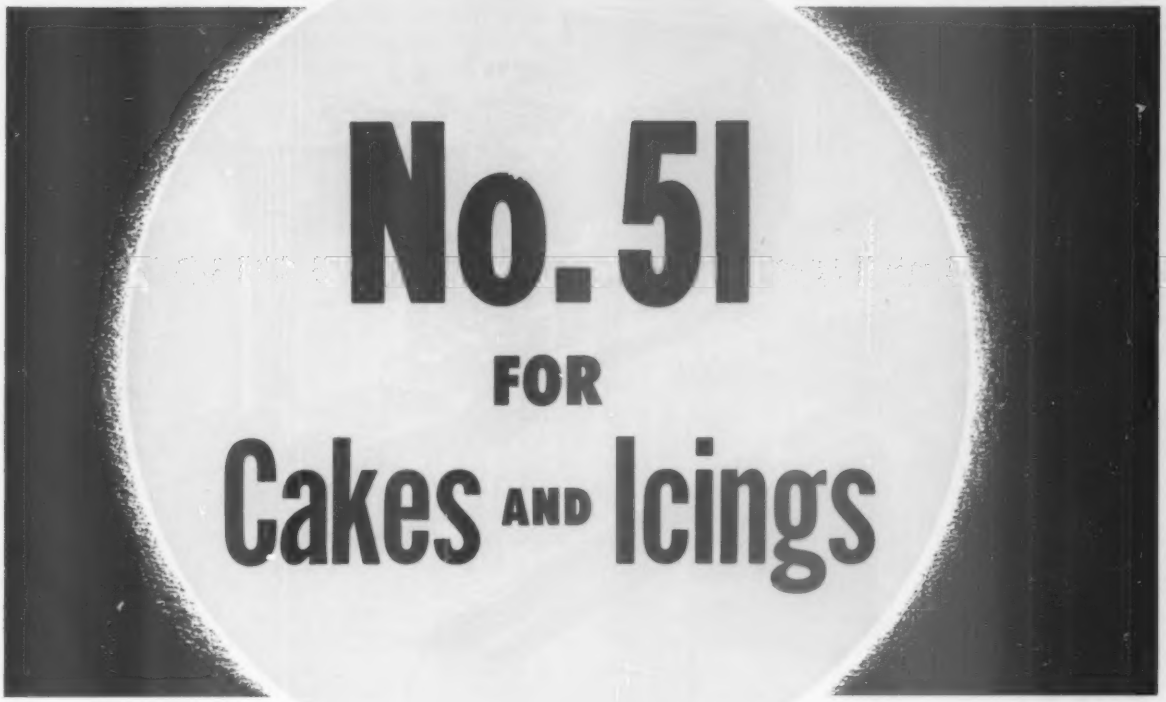

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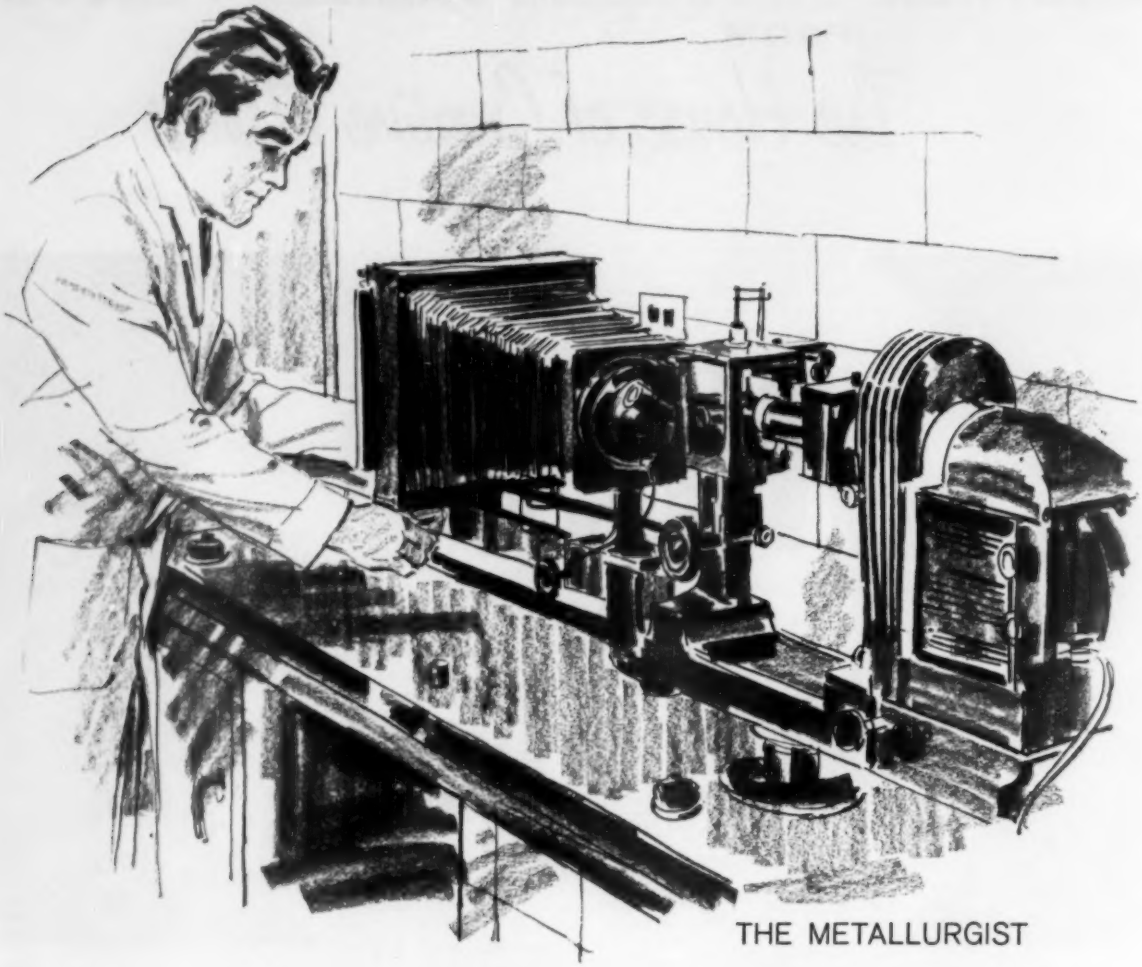

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pared to those of the untreated controls. Spraying steaks with chlortetracycline is more effective in retarding spoilage than wrapping steaks in chlortetracycline-impregnated film—at the levels of use employed in this experiment. When both types of treatment are employed, there is no additional shelf life for the steaks beyond that obtained with a chlortetracycline spray alone.

B. "In store" experiment. The data for carcass samples cut 2 days after slaughter are shown in Table 2.

The data in Table 2 indicate that the levels of chlortetracycline achieved by injection and/or spraying were adequate and similar to those obtained in previous experiments of this type. The residues of chlortetracycline after spraying and/or after injection with chlortetracycline were found to be uniformly distributed in or on the meat. There was no gross contamination of the carcasses, based on microbial counts.

TABLE 2

Chlortetracycline assays and microbial counts of samples from injected and sprayed carcasses stored at 40° F.

Treatment		CTC γ/g. meat[1]			Microorganisms x 10^6/g. meat[1]		
Injection	Spray	Neck	Round	Tenderloin	Neck	Round	Tenderloin
None	None	0	0	0	0.02	4.7	0.02
CTC	None	0.62	0.82	0.86	0.01	0.03	0.02
None	CTC	0.27	0.28	0.16	0.01	0.27	0.04
CTC	CTC	0.94	0.97	1.19	0.002	0.02	0.004

[1] Averages of 4 carcasses each.

The data for the samples cut up and packaged 3 days after slaughter are presented in Table 3.

The data for the samples cut up and packaged 6 days after slaughter are presented in Table 4.

The data for the samples cut up and packaged 7 days after slaughter are presented in Table 5. This is an average of 2 complete sets of sides.

A study of Tables 3, 4 and 5 reveals that cut-up packaged meat had a longer shelf life when packaged 3 days after slaughter than when packaged 6 or 7 days after slaughter. The concentrations of chlortetracycline obtained in the meat in this experiment were in descending order: injection plus spray, injection, spray, and finally, impregnated cellophane; the effectiveness followed the same order.

TABLE 4

Chlortetracycline assays and microbial counts on steak and ground meat treated by injection, spray and film and stored at 40° F.

Steak							
Treatment			CTC γ/g. meat[1]	Microorganisms x 10^6/g. meat[1] Days after packaging			
Injection	Spray	Film		0	3	5	8
None	None	Plain	0	0.014	0.79	3.54	341
None	None	CTC	0.34	0.02	0.22	0.33	16.4
CTC	None	Plain	0.4	0.16	0.09	0.33	1.37
CTC	None	CTC	0.74	0.13	0.06	0.29	0.88
None	CTC	Plain	0	0.03	0.43	58.1	456
None	CTC	CTC	0.43	0.012	0.07	5.39	235
CTC	CTC	Plain	0.22	0.12	0.02	0.13	15.98
CTC	CTC	CTC	0.57	0.11	0.03	0.30	12.8
Ground meat							
None	None	Plain	0	0.024	0.12	5.34	301
None	None	CTC	0.14	0.02	0.09	2.87	232
CTC	None	Plain	0.32	0.07	0.11	0.08	0.52
CTC	None	CTC	0.43	0.041	0.07	0.05	0.16
None	CTC	Plain	0.10	0.015	0.039	0.34	80.4
None	CTC	CTC	0.27	0.01	0.026	0.16	17.7
CTC	CTC	Plain	0.23	0.04	0.032	0.033	0.56
CTC	CTC	CTC	0.32	0.052	0.056	0.033	0.45

[1] Averages of 2 packages each.

Organoleptic findings. In general the organoleptic results followed the microbiological findings. The treated film definitely aided color retention. Color retention was better in areas where the meat was in intimate contact with the film as opposed to areas with an air space between film and meat. This was true whether the film was treated or not. The undersurface of both steaks and ground meat was brighter even when evidence of grayness appeared on the top surface.

Essentially no difference in over-all appearance was

TABLE 3

Chlortetracycline assays and microbial counts on steak and ground meat treated by injection, spray and film and stored at 40° F.

Steak								
Treatment			CTC γ/g. meat[1]	Microorganisms x 10^6/g. meat[1] Days after packaging				
Injection	Spray	Film		0	3	5	8	10
None	None	Plain	0	0.013	0.013	8.56	82.7	897
None	None	CTC	0	0.012	0.012	0.73	60.1	276
CTC	None	Plain	0.75	0.005	0.002	0.001	1.38	13.6
CTC	None	CTC	0.76	0.0001	0.0007	0.0023	0.72	1.03
None	CTC	Plain	0	0.002	0.0008	0.14	12.4	225
None	CTC	CTC	0	0.001	0.007	0.19	12.5	87.9
CTC	CTC	Plain	0.44	0.006	0.001	0.012	0.57	5.88
CTC	CTC	CTC	0.67	0.005	0.004	0.005	0.29	0.25
Ground meat								
None	None	Plain	0	0.057	1.03	57.8	101.4	346
None	None	CTC	0.02	0.051	0.73	55.1	144.2	91.1
CTC	None	Plain	0.83	0.029	0.03	0.013	0.02	0.26
CTC	None	CTC	0.83	0.024	0.019	0.11	0.008	0.25
None	CTC	Plain	0.15	0.027	0.038	0.28	0.94	31.0
None	CTC	CTC	0.20	0.02	0.02	0.14	0.69	7.3
CTC	CTC	Plain	0.77	0.013	0.004	0.019	0.015	0.2
CTC	CTC	CTC	0.87	0.02	0.009	0.029	0.005	0.25

[1] Averages of 2 packages each.

TABLE 5

Chlortetracycline assays and microbial counts on steak and ground meat treated by injection, spray and film and stored at 40° F.

Treatment			CTC γ/g. meat[1]	Microorganisms x 10^6/g. meat[1] Days after packaging			
Injection	Spray	Film		0	3	5	8
Steak							
None	None	Plain	0	0.051	4.34	305	581
None	None	CTC	0.17	0.008	7.18	51.4	376
CTC	None	Plain	0.23	0.008	0.043	0.25	68.8
CTC	None	CTC	0.30	0.005	0.17	0.17	3.35
None	CTC	Plain	0	0.004	2.73	6.46	201
None	CTC	CTC	0.17	0.004	0.24	5.5	468
CTC	CTC	Plain	0.61	0.004	0.048	0.113	1.59
CTC	CTC	CTC	0.83	0.007	0.095	0.008	2.0
Ground meat							
None	None	Plain	0	0.147	6.69	2850	1380
None	None	CTC	0.16	0.17	2.21	131	1190
CTC	None	Plain	0.19	0.088	0.11	0.21	6.68
CTC	None	CTC	0.43	0.074	0.074	0.11	3.49
None	CTC	Plain	0.36	0.436	0.237	0.33	4.94
None	CTC	CTC	0.45	0.02	0.02	0.14	0.69
CTC	CTC	Plain	2.76	0.102	0.09	0.16	0.77
CTC	CTC	CTC	1.45	0.286	0.067	0.154	0.97

[1] Averages of 4 packages each.

observed between the injected, film-treated samples and the injected, sprayed, film-treated samples. The samples from injected aminals were superior to those from sprayed carcasses or control carcasses wrapped in treated film.

Effective levels of chlortetracycline have been obtained in meat in these experiments and clearly demonstrate that the antibiotic may be applied by a number of procedures. The effectiveness of chlortetracycline in prolonging the salability of packaged meat is related to the level of antibiotic obtained in the meat and that level is of course related to the method of application. Although the film impregnated with chlortetracycline proved less effective in prolonging shelf life than either the spray or injection application methods, it is easily seen that the chlortetracycline assays for film-treated samples were usually lower than those for other samples. One would expect that meat would have a longer shelf life if the animal had been injected with chlortetracycline than if the sides were merely sprayed on the surface with a solution of the antibiotic. The data bear out this expectation, not only microbiologically but organoleptically as well. It is reasonable to predict that if the amount of chlortetracycline applied as a spray or in a film were at a level equal to that obtained by the injection technique, the shelf life would approach that obtained by the injection method of applying chlortetracycline. It is important to note that the meat was unsalable organoleptically slightly before the microbial counts had increased to unacceptable levels, indicating that the housewife's criteria of freshness (appearance and odor) have not been altered by the use of an antibiotic.

SUMMARY AND CONCLUSIONS

The effectiveness of chlortetracycline for extending the shelf life of beef was demonstrated and various methods for applying the antibiotic were compared for such use. The ability of the antibiotic to prolong the salability of beef was dependent upon its level in the meat and that level was, in turn, related to the application method. At the amounts used, chlortetracycline was most satisfactory when administered by both an intravenous injection to the live animal immediately before slaughter, and as a spray immediately after slaughter. In order of decreasing effectiveness were the injection, the spray and finally, the impregnated cellophane methods of application.

From data reported, it may be concluded that the use of chlortetracycline applied directly as a spray to beef cuts or as an impregnated film will make "in plant" packaging of meats a possibility. Chlortetracycline applied to meats by an injection to the live animal, as a carcass or retail cut spray, or as an impregnated film will also increase the period of salability of meat packaged at the retail level.

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Prevention of Darkening in Frozen Broilers[a,b,c]

Cordelia Ellis and J. G. Woodroof
Georgia Experiment Station, Experiment, Georgia

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THE BROILER INDUSTRY has made a phenomenal growth during the last two decades. Production in the United States in 1958 was 1,552 million broilers valued at $988 million. Georgia had the highest production of any state with 292 million broilers valued at $164 million. The quantity of poultry frozen also has steadily increased, from less than 10 million pounds in 1937 to 130 million pounds in 1947 and 530 million pounds in 1957.

Progress in selecting the birds and improving sanitary conditions has been marked, but one of the problems of the frozen broiler industry is that of darkening of the meat near the bone of frozen young chickens. Results of a series of experiments conducted during the past ten years indicate that bone darkening is a problem, and that it may be prevented by preheating the product to 180° F. prior to freezing (Figures 1, 2, 3, 4). Six experiments were conducted to evaluate the influence of various methods of handling young chickens prior to freezing on meat darkening and sensory qualities. It is believed that some of the treatments used can be adapted to commercial production.

Stewart, Hanson, Lowe, and Austin *(7)* noticed that the bones and proximate flesh of cooked frozen chickens were commonly darker than in cooked fresh chickens. Koonz *(3)* reported that the pigments of the bone marrow of young chickens leached through the spongy bone wall during freezing and thawing, but that the resulting discoloration in no way affected the palatability of the meat. Koonz and Ramsbottom *(4)*, studying the bones of beef, lamb, veal, and poultry, found that the bones of young animals, containing more hemoglobin than those of fully mature animals, were consistently darker after freezing and thawing. This was especially true of the legs of chickens.

Woodroof and Shelor *(8)* found that darkening of the flesh of legs, thighs, backs, and the second joints of wings of frozen young chickens was caused by bloody marrow leaching through the bone during freezing, thawing, and cooking. It did not affect the flavor, aroma, or texture of the chicken and was not associated with bacterial spoilage. Darkening was confined to young chickens before the bones were calcified, and was not found in mature chickens. The white meat was unaffected. Method of bleeding or method of chilling before freezing had little or no effect on meat darkening. Blanching cut-up chicken in hot fat before freezing prevented meat darkening, but adversely affected the flavor. Darkening increased consistently during storage at 10° F., slightly at 0° F., and none at −20° F.

Brant and Stewart *(1)* stated that there was no significant difference in the discoloration of the bones of birds between the ages of 7 and 14 weeks but darkening was reduced in those 16 to 17 weeks old. They found that genetic background, time of bleeding, chilling prior to freezing, freezing rate, storage temperature, length of storage period, method of cooking, and the refreezing of defrosted stock made no

[a] Technical Paper No. 356, Journal Series, Georgia Experiment Station, Experiment, Georgia.
[b] Presented at the 19th Annual Meeting of the Institute of Food Technologists, Philadelphia, May 20, 1959.
[c] S. R. Cecil ran chemical and statistical analyses and Ethyl Shelor conducted the taste panel for Experiment 1.

Figure 1. Skeleton of chicken showing shaded areas where darkening of bones and meat may occur during freezing, thawing and cooking.

difference in the amount of darkening. However, darkening was reduced by roasting for 30 minutes before freezing and by immediate cooking after rapid thawing, provided the birds were stored at −30° F. There was no darkening when the marrow was removed from the bones.

Essary *(2)* found that a two-minute heating period with microwaves eliminated a large percentage of bone discoloration in broiler halves. A four-minute heating period eliminated all discoloration; however, longer heating periods were undesirable because the meat was partially cooked.

EXPERIMENTAL PROCEDURE AND RESULTS

Six separate experiments were conducted in an effort to determine factors associated with and methods of preventing meat darkening in frozen poultry.

Experiment 1

To determine the effects of sex, age, minerals and vitamin D in the diet, and of preheating before freezing 8 lots of 13 chickens each were grown under controlled temperature, light, and feed with varying amounts of vitamin D, riboflavin, manganese, phosphorus, and calcium. About 100 yard-grown chickens were used for comparison.

The fastest growing chickens were killed when 66 days old at an average weight of 2 pounds and 12 ounces; the remainder were killed when 73 days old, at an average weight of 2 pounds and 15 ounces. Methods of killing, dressing, and freezing were similar to those used in commercial practice. After one month storage at 0° F., the product was thawed, cooked, and examined by a score panel; the meat was analyzed for moisture and the bones for ash, calcium, manganese, and phosphorus *(4)*. Results were evaluated statistically by applying the F-test and the simple correlation methods given by Snedecor *(5)*.

Results

1. Preheating the pieces to an approximately half cooked stage before freezing prevented meat darkening near the bone, although the flavor was somewhat adversely affected. Methods of preheating—broiling, stewing, frying in deep fat at 350° F. —were apparently equally satisfactory.

2. Darkening was less in yard-grown chickens, probably due to the 2 weeks longer required to reach broiler weight, and more calcification of the bones.

3. Cockerels were found to have more meat darkening than pullets of equal age, and darkening in chickens reaching 2¾ pounds in 66 days was more intense than in those requiring 73 days to reach this weight, especially among pullets. Rate of gain showed that pullets approached maturity faster than cockerels at this age; and bone ash, which was correlated with darkening in pullets, was higher than in cockerels.

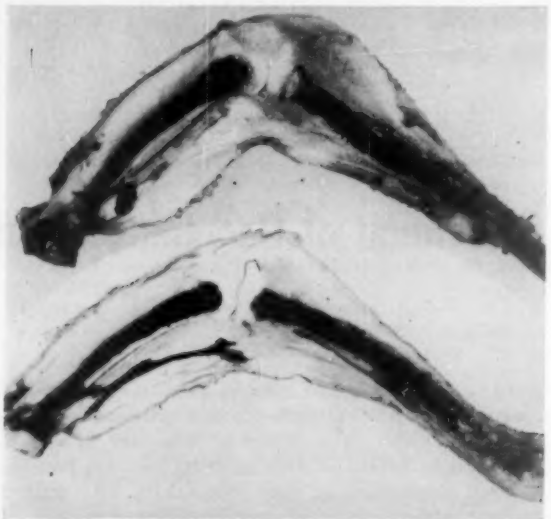

Figure 2. Long sections of chicken legs. (Upper) leg and thigh that were discolored when blood was forced out of the bone due to pressure developed during freezing and subsequent cooking. (Lower) leg and thigh that remained virtually free of meat darkening after being preheated to 180° F. prior to freezing. Heating precipitated the marrow and prevented its leaching through the bone and discoloring the meat.

4. A feed low in calcium produced chickens with increased darkening, and a large excess of calcium in the feed resulted in some decrease in darkening in cockerels, although somewhat depressing growth.

5. Excess amounts of vitamin D, with or without excess calcium, resulted in significant increases in darkening, the increases being greater with cockerels.

6. Length of storage did not significantly influence the amount of meat darkening. Meat near the bone of chicken frozen, as long as 8 years, was no darker than that frozen for only one week.

Experiment 2

An experiment was conducted to determine the effect on meat darkening when pieces of chicken were preheated to 3 internal temperatures by 4 methods. Legs and thighs of young chickens were obtained fresh from a commercial dressing plant and preheated (Table 1) to internal temperatures of 140°, 160°, or 180° F., by 4 methods of heating: deep fat at 350° F., live steam at 210° F., radiant heat at 350° F., and microwaves. Internal temperatures were measured by thermometers inserted

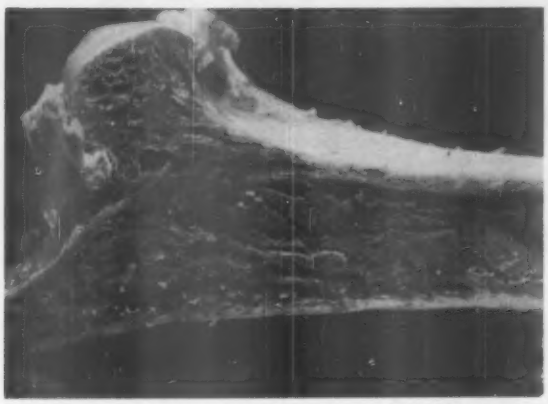

Figure 3. Darkening of meat was due to loss of bloody marrow through the porous bone caused by pressure produced by freezing. Shown here is a long section of a chicken leg bone near the joints containing bloody marrow.

into the bone of representative pieces of each sample. Temperatures of pieces heated in the microwave oven were measured immediately after removal from the oven; all other temperatures were measured during heating.

After preheating, the legs and thighs were frozen overnight at −20° F., battered and breaded, packaged in polyethylene bags, and stored at 0° F. for one week. The pieces were partially thawed and fried in deep fat at 300° F. until tender and brown, which required about 20 minutes. They were then evaluated for meat and bone darkening by a panel of 5 judges. Changes in weight of each piece were recorded after each step in preparation.

Results

1. All methods of preheating reduced meat darkening in frozen young chicken thighs and legs without noticeably affecting the eating qualities.

2. Preheating with microwaves required the shortest time and resulted in least weight loss and highest over-all yield of cooked product. Order of preference for other methods was: steam, radiant heat, and deep fat.

3. Preheating to 140° F. in deep fat resulted in least darkening of both meat and bone, followed by preheating with microwaves and radiant heating.

4. Preheating to 160° F. reduced meat and bone darkening, as compared to 140° F., radiant heating was slightly more effective, followed by microwaves, steam, and deep fat.

5. Preheating to 180° F. was the most effective method for reducing bone and meat darkening; pieces heated by microwaves, which were particularly effective, received the highest of all the ratings (Figures 5 and 6).

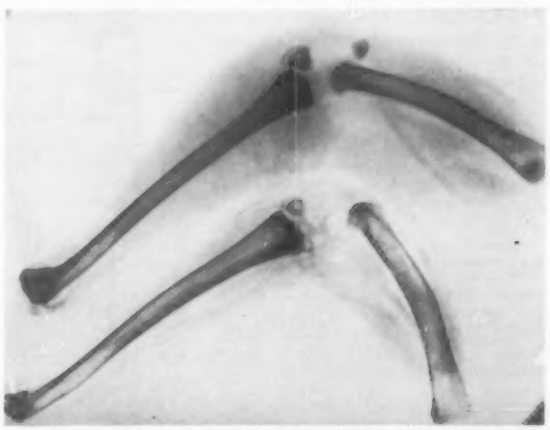

Figure 4. X-ray photograph of two chicken legs; (Upper) showing intense darkening of bone and meat; (Lower) showing both bone and meat practically free of darkening.

Experiment 3

Results from the previous experiment having shown that preheating thighs and legs of young chickens to an internal temperature of 180° F., was highly effective in preventing meat and bone darkening during freezing and subsequent cooking; an experiment was run in which small legs, large legs, small thighs, and large thighs, averaging 46, 104, 55, and 123 g., respectively, were preheated to 180° F. prior to freezing. Steam, radiant heat, and deep fat were used as shown in Table 2, and temperatures were measured by thermocouples.

The pieces of chicken were obtained fresh from a commercial dressing plant, preheated in live steam at 210° F., with radiant heat at 350° F., or in deep fat at 350° F., and frozen at −20° F., overnight. They were then battered, breaded, packaged individually in polyethylene bags, and held at 0° F. for 4 months. The pieces were partially thawed, fried in deep fat at 300° F. until brown, and evaluated by a taste panel of 5 judges.

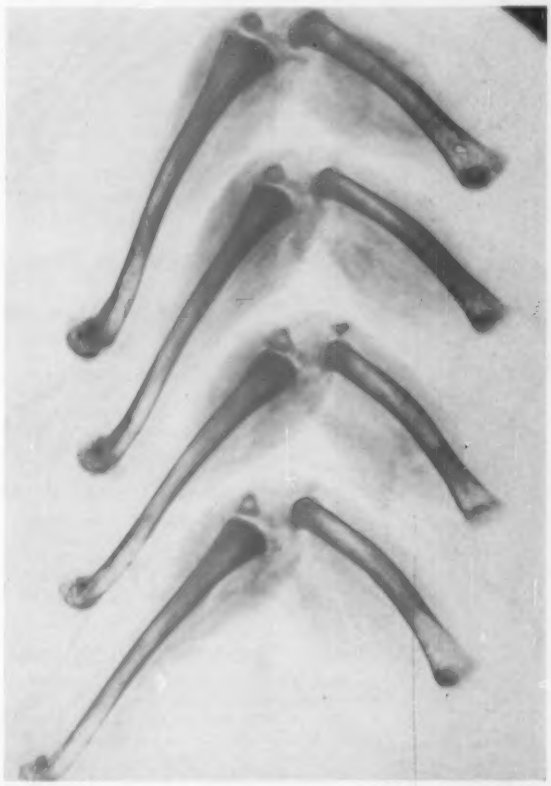

Figure 5. X-ray photograph of four chicken legs showing decrease in the amount of meat darkening, from top to bottom. Heating chicken legs to 180° F. before freezing was found to be the most effective means of preventing meat darkening.

Results

1. In small legs preheated to 180° F. meat darkening was practically eliminated; however, there was a noticeable loss in flavor. Order of preference was steam, deep fat, and radiant

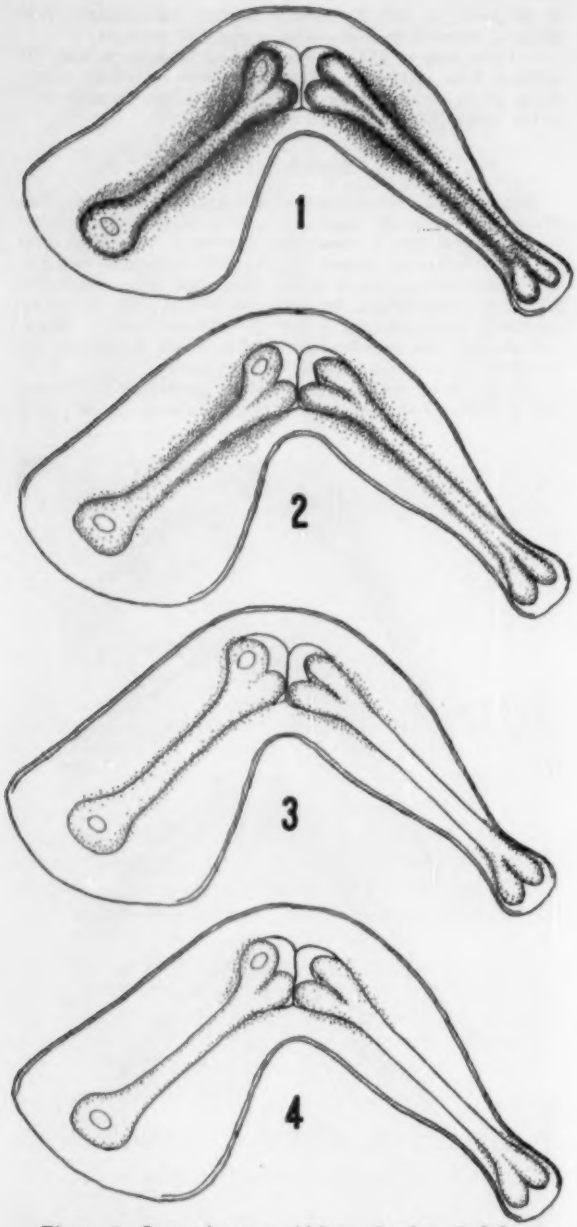

Figure 6. Legs of young chickens showing shaded areas where darkening of bones and meat occurred when (1) prepared, frozen, thawed, and fried in usual way; (2) preheated five minutes under 10 pounds steam pressure and allowed to thaw completely before frying; (3) same as above except fried directly from the frozen state; (4) preheated three minutes with microwaves, frozen and fried directly from the frozen state.

heat. Total yield of the preheated product was about 20% less than that of pieces frozen without preheating.

2. With large legs, meat darkening was also practically eliminated, and no loss of flavor occurred when preheated by steam or deep fat. Radiant heat resulted in some loss of flavor.

3. Heating with either steam or radiant heat practically eliminated meat darkening in small and large thighs but resulted in a loss of flavor. Deep fat was less effective for preventing meat darkening.

4. Although preheating was highly effective in preventing meat darkening in young chicken thighs and legs of all sizes, there was much better flavor retention in the larger pieces.

TABLE 1

The effects of preheating chicken thighs and legs to 140°, 160°, and 180° F. on meat and bone darkening and weight losses

Preheating		Weight		Freedom from darkening[1]	
Method	Time	Heating loss	Cooked product	Meat	Bone
	min.	*%*	*%*	*rating*	*rating*
None	.....	.....	84.6	5.8	3.8
Internal temperature 140° F.					
Deep fat	2.0	17.9	78.0	5.8	6.4
Radiant heat	21.0	7.1	87.9	3.6	2.6
Microwaves	1.75	4.2	85.9	5.0	4.6
Internal temperature 160° F.					
Deep fat	3.0	17.1	85.0	4.8	5.2
Steam vapor	15.0	4.3	82.8	6.2	6.4
Radiant heat	26.0	13.5	75.2	7.2	7.8
Microwaves	2.0	4.5	89.6	7.0	6.6
Internal temperature 180° F.					
Deep fat	4.5	21.3	78.7	4.8	6.8
Steam vapor	26.0	12.4	75.4	5.8	6.8
Radiant heat	36.0	25.8	72.7	6.0	6.8
Microwaves	3.0	10.7	77.0	8.0	8.0

[1] Ratings from 10 (no darkening) to 1 (severe darkening).

Experiment 4

A fourth experiment was conducted in which thighs from young chickens were preheated in deep fat at 350° F., with steam at 10 pounds pressure, by radiant heat at 350° F., or with microwaves, using several kinds of containers, as shown in Table 3. Freezing, packaging, and storing of the samples were the same as for Experiments 2 and 3. The chicken was fried directly from the frozen state. Tenderness, flavor, and freedom from darkening were evaluated by a score panel.

The weight of the chicken thighs preheated by microwaves ranged from 98 to 109 g. and, because of the small variation in weight, no adjustment was made in the preheating time.

TABLE 2

The effect of preheating small and large chicken legs and thighs to 180° F. by three methods on heating loss, yield of cooked product, freedom from meat darkening, and flavor

Preheating		Weight			Freedom from meat darkening[1]	Flavor[2]
Method	Time	Fresh	Heating loss	Cooked product		
	min.	*g.*	*%*	*%*	*rating*	*rating*
Small legs						
None	.....	58.0	.....	91.9	3.0	7.0
Steam vapor	9.0	46.3	20.5	70.3	8.0	5.0
Radiant heat	30.0	45.6	26.8	71.0	7.0	4.5
Deep fat	5.0	51.4	28.9	74.7	9.0	4.0
Large legs						
None	.....	88.3	.....	90.3	3.0	7.0
Steam vapor	16.5	103.8	16.6	76.6	8.0	7.5
Radiant heat	50.0	104.7	26.2	71.6	7.0	6.0
Deep fat	10.25	95.5	28.3	76.9	7.5	8.5
Small thighs						
None	.....	46.0	.....	98.5	2.0	6.0
Steam vapor	8.5	48.0	24.3	73.4	9.0	6.0
Radiant heat	34.0	55.9	35.8	71.0	8.0	5.0
Deep fat	6.5	60.9	39.1	71.0	6.0	5.5
Large thighs						
None	.....	126.0	.....	91.0	2.0	7.0
Steam vapor	14.5	123.0	22.7	72.9	7.0	8.0
Radiant heat	48.0	127.5	28.8	66.4	9.0	6.0
Deep fat	9.0	111.9	37.0	71.0	6.0	6.0

[1] Ratings from 10 (no darkening) to 1 (severe darkening).
[2] Ratings from 10 (excellent) to 1 (extremely poor).

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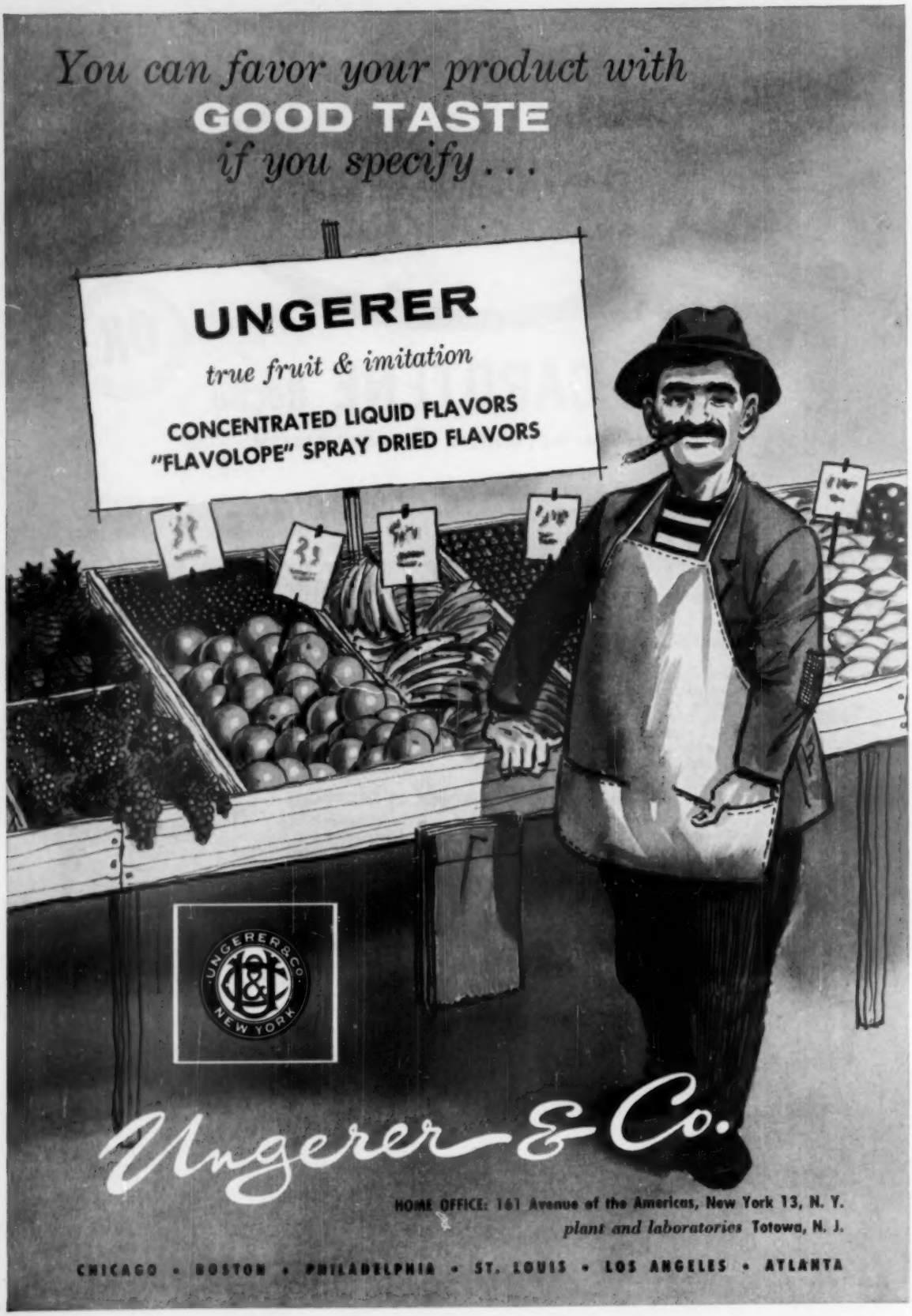
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Results

1. Preheating with microwaves for three minutes practically eliminated darkening and resulted in a moist, tender, and flavorsome product. Weight loss from preheating was 18.6%, and total yield of cooked product was 74.7% of the fresh weight.

2. Chicken thighs preheated by microwaves in a covered dish, with or without added water, or in mylar bags also had very little darkening; however, the flavor was rated as "warmed-over" or stale. The chicken in a covered dish with added water had a higher weight loss, 24.0%, than the uncovered chicken.

3. Cicken steamed in a pressure saucepan at 10 pounds pressure for 5 minutes showed no darkening and received a good flavor rating. Weight loss was 16.5%.

TABLE 3

The effect of preheating chicken thighs to 180° F. by four methods on heating loss, yield of cooked product, freedom from meat darkening, and flavor

Preheating		Weight		Freedom from meat darkening[1]	Flavor[2]
Method	Time	Heating loss	Cooked product		
	min.	*%*	*%*	*rating*	*rating*
None	....	.....	77.3	5.0	9.0
Deep fat	5	28.9	67.8	7.0	5.0
	10	40.9	60.4	8.0	8.0
Steam pressure	5	16.5	68.9	10.0	9.0
	10	24.3	63.8	10.0	7.5
Radiant heat not wrapped	15	8.1	83.5	6.0	9.0
	30	20.8	75.3	10.0	6.0
wrapped in foil	15	7.3	82.5	5.0	5.5
	30	24.9	68.5	10.0	5.0
Microwaves not covered	2	7.2	85.1	7.5	9.0
	3	18.6	74.7	9.0	8.0
in covered dish, no water	3	20.6	72.1	9.0	7.0
¼ inch water	3	24.0	69.9	10.0	7.0
in mylar bags	3	20.0	77.0	9.0	6.5

[1] Ratings from 10 (no darkening) to 1 (severe darkening).
[2] Ratings from 10 (excellent) to 1 (extremely poor).

4. Thighs preheated by radiant heat for 30 minutes, uncovered or foil-wrapped, had no darkening; however, the flavor was termed *warmed-over*, *boiled*, and *bitter*. Heating losses were 20.8 and 24.9%, respectively.

5. Deep fat as a preheating method resulted in lessened darkening, a very high weight loss, and a low flavor rating.

6. Flavor losses and weight losses were proportional to the length of time of preheating, irrespective of the method of heating.

Experiment 5

An experiment was conducted to determine the effects of very rapid freezing on meat darkening and other qualities of fresh young chickens. Chicken legs and thighs were obtained from a commercial dressing plant and frozen by 5 methods as shown in Table 4. The pieces were packaged individually and held at 0° F., for 5 days. They were then fried, without previous thawing, in deep fat at 300° and evaluated for meat darkening and tenderness by a panel of 5 judges.

Results

1. Of the 5 rates of freezing used, the most rapid was with liquid CO_2, which reduced meat darkening, reduced juiciness, and caused decided separation of the muscles. The meat had a pleasing color, but was slightly dry and stringy, and the separate muscles could be easily pulled apart. There was no significant change in the moisture content due to method of freezing.

TABLE 4

Effect of rate of freezing fresh young chicken thighs and legs on meat darkening and other qualities

Freezing		Condition of chicken			
		Raw	Cooked		
Method	Temperature	Moisture	Freedom from darkening[1]	Texture juiciness[2]	Muscle separation[2]
	° F.	*%*	*rating*	*rating*	*rating*
None (fresh)	.....	75.5	10	10 juicy	10 none
Frozen in air	0	73.3	1	9 juicy	9 slight
Frozen in air	—20	75.6	2	8 slightly dry	8 slight
Frozen on plates	—20	73.2	2	8 slightly dry	8 slight
Very rapid freezing solid CO_2	—170	73.7	3	3 dry	3 decided
Very rapid freezing liquid CO_2	—170	74.6	4	3 dry, tough	2 decided

[1] Ratings from 10 (no darkening) to 1 (severe darkening).
[2] Ratings from 10 (excellent) to 1 (extremely poor).

2. Chicken frozen with solid CO_2 reached the same temperature as with liquid CO_2, but the rate of freezing was slower. This method of freezing reduced meat darkening and produced slightly less "dryness" and muscle separation.

3. Freezing at −20° F. reduced meat darkening slightly and caused slight muscle separation whether the chicken was frozen quickly on metal plates or slightly slower in still air.

4. The chicken frozen slowly at 0° F. was very dark, juicy, and of uniform texture. This was comparable to fried unfrozen chicken except for the meat darkening.

Experiment 6

An experiment was conducted to determine the amount of darkening in broiler legs and thighs after 2 years in freezing storage. They were treated by microwaves or radiant heat and wrapped individually in aluminum foil before freezing; half of the samples were cooked directly from the frozen state, and half after thawing for 24 hours in a refrigerator at 40° F., as shown in Table 5. After frying in deep fat at 300° F., samples were rated on freedom from darkening of meat and bone, flavor and moistness of the meat.

Results

1. Meat and bone darkening was effectively controlled by preheating legs and thighs with microwaves for 1½ minutes, or with radiant heat at 350° F., for 12 minutes. There was no loss in flavor with either of these treatments.

2. There was no apparent increase in meat and bone darkening due to freezing storage for 2 years.

3. There was a marked increase in rancidity, staleness and "dryness" of the meat when preheated with microwaves for more than 3 minutes or with radiant heat for more than 25 minutes.

4. There was an increase in darkening of meat and bones when the chicken was thawed for 24 hours in a refrigerator at 40° F., before frying, as compared with that cooked directly from the frozen state.

SUMMARY

Darkening of poultry meat by seepage of marrow through the leg and thigh bones of young chickens due to freezing, thawing, and cooking is a major problem. A series of experiments showed that heating chicken legs and thighs to an internal temperature of 180° F., before freezing effectively controlled meat darkening. This was due to heat coagulation of the marrow prior to freezing.

The methods of preheating, rated in order of preference based on control of darkening, low weight loss,

TABLE 5

Amount of darkening in broiler legs and thighs, heated by microwaves or radiant heat before freezing, held for two years in frozen storage, and cooked from the frozen state or after thawing

Preheating		Thawing	Freedom from darkening[1]		Flavor[2]	Moistness[2]
Method	Time		Meat	Bone		
	min.	*hrs.*	*rating*	*rating*	*rating*	*rating*
None	....	none	4	4	7 stale	8 moist
		24	3	3	6.5 off	8 moist
Microwaves	½	none	7 white	7	7.5 stale	8 moist
		24	7 white	7	7 slightly stale	8 moist
	1	none	8.5 white	8.5	6.5 slightly stale	7.5 slightly dry
		24	8.5 white	8	6 slightly stale	7.5 slightly dry
	1½	none	9 white	9	6.5 slightly stale	7.5 slightly dry
		24	9 white	9	6 slightly stale	7.5 slightly dry
	2	none	9 white	9	5 rancid	6 dry
		24	9 white	9	4 rancid	6 dry
	3	none	7 grayed	9	4 rancid	4 dry
		24	6 grayed	9	3 rancid	4 dry
	4	none	6 grayed	9	2 fishy and rancid	3 very dry
		24	6 grayed	9	2 fishy and rancid	3 very dry
	6	none	5 yellowed	9	2 burned and rancid	2 very dry
		24	5 yellowed	9	2 burned and rancid	2 very dry
Radiant heat	2½	none	6 yellowed	5.5	7 slightly stale	8 moist
		24	6 yellowed	5	7 slightly stale	8 moist
	7	none	7.5 white	7	7 slightly stale	8 moist
		24	5 slightly grayed	6	7 slightly stale	8 moist
	12	none	7.5 white	8	7.5 slightly stale	8 moist
		24	7 white	7	7 slightly stale	8 moist
	17	none	7 white	7	6 stale	8 moist
		24	7 white	7	5 stale	8 moist
	22	none	9 white	9	5 rancid	6 slightly dry
		24	7 grayed	9	4 rancid	6 slightly dry
	27	none	8 white	9	5.5 rancid	5 dry
		24	7 white	9	5 rancid	5 dry
	37	none	8 white	9	5 rancid	3 very dry
		24	7 slightly grayed	9	4 rancid	3 very dry

[1] Ratings from 10 (no darkening) to 1 (severe darkening).
[2] Ratings from 10 (excellent) to 1 (extremely poor).

rapidity of treatment, and flavor retention, were: (a) electronic oven using microwaves for 2–3 minutes, (b) 10 pounds steam pressure for 5–10 minutes, (c) live steam at 210° F. for 15–20 minutes, (d) oven with radiant heat at 350° F. for 25–30 minutes, and (e) deep fat at 350° F. for 5–10 minutes. A range in time of treatments was required for variations in size of pieces of chicken. Prolonging heating, after a temperature of 180° F. was reached, increased moisture and flavor losses. Chicken preheated in foil, mylar bags, or in a covered dish had a "warmed-over" flavor.

The rate of freezing somewhat influenced darkening and texture of the meat. Chicken frozen slowly at 0° F. had the darkest meat, but was moist and uniform in texture. That frozen very rapidly with liquid CO_2 at −170° F. was slightly less dark, but was "dry," stringy, and the muscles were easily separated. The quality of chicken frozen at −20° F. was intermediate between these two extremes. Chicken cooked directly from the frozen state was less dark than that cooked after thawing.

Chicken preheated by microwaves (4–5 pieces at a time) for 2 minutes or less and held in frozen storage for two years was stale, but still juicy, while that heated for a longer time by microwaves or more than 17 minutes by radiant heat was "dry," and rancid.

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Notes and Letters

Effect of Illumination on Color of Frozen Peas Packaged in a Transparent Film

SOME PROCESSORS have recently started using polyethylene bags as packages for frozen vegetables and others are considering their use. Obvious advantages are lowered packaging cost and greater eye appeal. Several processors expressed interest in knowing whether less obvious disadvantages might develop. For example, what effect does exposure to light in retail storage cabinets have on color? Results of a simple experiment on peas provide a partial answer.

Preparation of samples. Commercially frozen Dark-skin Perfection peas in cases of 24 10-oz. retail packages were obtained from a distributor. The entire quantity was screened to break clusters and was mixed to obtain better sample uniformity. Samples consisted of 5-oz. portions placed in 5 x 3½ x 12-in. bags of 1.5 mil polyethylene, which were closed by twisting, folding, and fastening with a rubber band. All of these operations were carried out in a cold room at 0° F.

Exposure to light. Test packages were exposed to the light of two 20-watt fluorescent tubes (General Electric, Standard Cool White) in a single reflector placed 21 in. above the peas. Eight bags were placed in 2 rows of 4, centrally under the fixture. Similar exposures were made at 2 temperatures, 0° and 20° F. The light fixtures were operated in surroundings at the temperatures specified. Enough looseness was allowed in packaging the peas so that the bag could be flattened to expose a surface about 5 in. square. This meant that the peas were only 2 or 3 layers deep; thus a reasonably large percentage of the peas received illumination.

Positions of bags were systematically changed each day to reduce chances of uneven illumination. Also at this time, the contents were mixed by shaking and squeezing and the bags turned over.

An equal number of control samples, identically packaged, were placed in the same relative positions as the illuminated samples and at both test temperatures, but they were contained in corrugated cases to prevent exposure to light. These samples were handled daily just like the other samples so that differences would be due only to light.

Pairs of samples at each temperature and under each light condition were removed at weekly intervals over a 4-week period. These were held at −20° F. in the dark until they could be analyzed. One sample of each pair was used for measurements in the Gardner Automatic Color Difference Meter and the second used for chlorophyll determination. After color measurement, certain samples from the first group were tasted by a small panel.

Temperature changes. It was realized that the surfaces of the peas receiving illumination would be warmed to some extent. To devise means and carry out the measurement of this temperature rise was beyond the scope of the experiment undertaken but an estimate of its magnitude was made in a relatively simple fashion. A blackened copper block in which a thermocouple was embedded was placed in the situation which had been used for 20° F. storage and the temperature of the block recorded on a chart. Temperatures were recorded during successive periods of illumination and darkness. The time periods were of sufficient duration to include many cycles of the temperature caused by the on-off cycle of the refrigeration. An average temperature was determined for each light condition and the temperature was found to be less than 1° F. higher under illumination than in darkness. Because the black body is a more efficient absorber of radiant energy than green peas, the temperature difference of peas under illumination should be even less.

From previous experience with frozen peas the magnitude of the changes in color and flavor encountered could not have been produced by the small difference in temperature indicated. Therefore it is believed the changes involved are brought about by factors other than temperature. However, the reactions, whatever their nature, are temperature sensitive as indicated by the differences in response at 0° and 20° F.

Color changes. The Gardner Meter was set for reflectance measurements and standardized against a "Bath Green" tile, SBC-12. The peas were thawed before use and the samples divided approximately in half. A small amount of distilled water was placed in the cell (2½ inches diameter x 1 inch deep), and the peas from one half-package were placed in as close-packed orientation over the optical bottom as possible without breakage of the peas. Measurements of L, a_L, and b_L were made on each half-package; the cell was emptied and refilled with the same peas between readings. The same procedure was followed for the other half-package. Values for Gardner hue, a_L/b_L, are reported (Table 1) because they had been found to be correlated reasonably well with subjective color evaluations of frozen peas during storage.

From Table 1 it is clear that no change in color was indicated at either storage temperature up to 4 weeks in samples stored in the dark. A definite color change as early as one week at 20° F. was indicated when the illuminated samples were compared with the dark controls, and the change continued throughout the 4-week period. While there was a slight decrease in Gardner hue over the 4-week period for samples under illumination at 0° F. compared to the dark controls, the change was too small to be convincing. However, observers had no difficulty in distinguishing the illuminated 3- and 4-week samples at 0° F. from their controls on the basis of visible color change. The same was true at 4 days' storage and beyond for samples stored at 20° F.

Therefore, Gardner hue did not indicate well the color changes that were readily observable. (No other reading on the Gardner Automatic Color Difference Meter was any better.) The reason is that the color changes were spotty, resulting in a mottled appearance of the peas. Meter readings lead only to average values of appearance and are, therefore, much less sensitive in distinguishing differences. Figure 1 shows to a degree the changes observable in samples stored under illumination at 0° and 20° F. The advantage of use of lower storage temperatures to avoid unfavorable color changes in frozen peas under illumination is quite apparent.

Flavor changes. An informal taste panel compared dark versus

TABLE 1

Gardner hue, a_L/b_L, for frozen peas stored in polyethylene bags

Storage, weeks	At 0° F.		At 20° F.	
	Dark	Illuminated	Dark	Illuminated
1	0.95	0.96	0.97	0.78
2	0.97	0.94	0.92	0.64
3	0.93	0.91	0.93	0.51
4	0.95	0.90	0.94	0.45

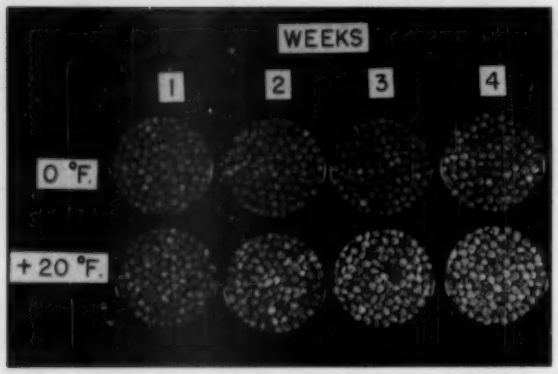


Figure 1. Effect of storage temperature upon appearance of frozen peas packaged in polyethylene and stored under illumination.

illuminated samples for two storage conditions, 20° F. for 1 week and 0° F. for 4 weeks. Samples were presented in cooked and unseasoned form under low intensity green light to avoid prejudging on the basis of color. Nine of 10 tasters found the illuminated sample stored 1 week at 20° F. to be unacceptable. "Oily" was the term most commonly applied to describe the flavor but there was far from complete agreement on a descriptive term. No preference was established for either sample stored 4 weeks at 0° F.

Chlorophyll changes. Chlorophyll analyses [5] were performed on the second sample of each pair by a method previously described (Dietrich, W. C., *Food Technol.*, 12, 428, 1958). The results are expressed as percentage conversion to pheophytin (Table 2). There was no clear-cut difference between illuminated samples and dark controls during storage at 0° F. over 4 weeks, whereas samples stored under illumination at 20° F. showed more conversion than their dark controls. The difference was substantial at one week and increased over the period of sampling.

The degree of conversion was much less than would have been expected from the appearance of the peas. This observation was readily understood when the seed coat was removed from the cotyledons. The color change was confined to the seed coat, while the cotyledons retained their brilliant green color. Had seed coats alone been analyzed, the degree of conversion would have been much higher for samples stored at 20° F. under illumination.

Frost formation. Frost formation within the bag was very much more pronounced in illuminated samples than in those stored in darkness. Even before one week had elapsed, the difference was clear at both storage temperatures. Frost formation is probably not related to the color changes observed, and measurements of relative amounts formed under the various circumstances were not made. Formation of frost in illuminated samples is understandable when one considers the transparency of the film and the ability of the peas to absorb some of the radiant energy. The temperature difference which must arise under these circumstances would be expected to result in sublimation of water from illuminated pea surfaces (at higher temperature) and condensation on the colder surfaces of unilluminated peas and bags.

[5] The author wishes to thank W. C. Dietrich for supervision of these analyses.

TABLE 2

Per cent conversion of chlorophyll to pheophytin in frozen peas stored in polyethylene bags

Storage, weeks	At 0° F.		At 20° F.	
	Dark	Illuminated	Dark	Illuminated
1	10.1	9.7	10.2	15.1
2	11.0	12.5	10.4	18.1
3	9.9	10.8	12.4	19.4
4	9.8	11.4	13.2	21.9

DISCUSSION AND CONCLUSIONS

This experimental evidence does not indicate that transparent packages should be avoided for frozen peas. However, it does indicate the need for great care in storing peas packaged in transparent films. The place where light exposure would be expected is the retail cabinet. The light intensity used in these experiments was selected as being somewhat greater than might be encountered in an average store.

The great advantage of strict adherence to 0° F. or lower was well demonstrated. Color change occurred approximately 5 to 10 times faster at 20° than at 0° F. Observable changes in color of the transparent packs occurred in 4 days at 20° F. and in 3 weeks at 0° F. and a pronounced flavor change, making the peas unacceptable, was found after 1 week at 20° F. Rapid turn-over is expected in a retail storage cabinet, where exposure to light will be encountered, and if it is sufficiently rapid no problem would be expected.

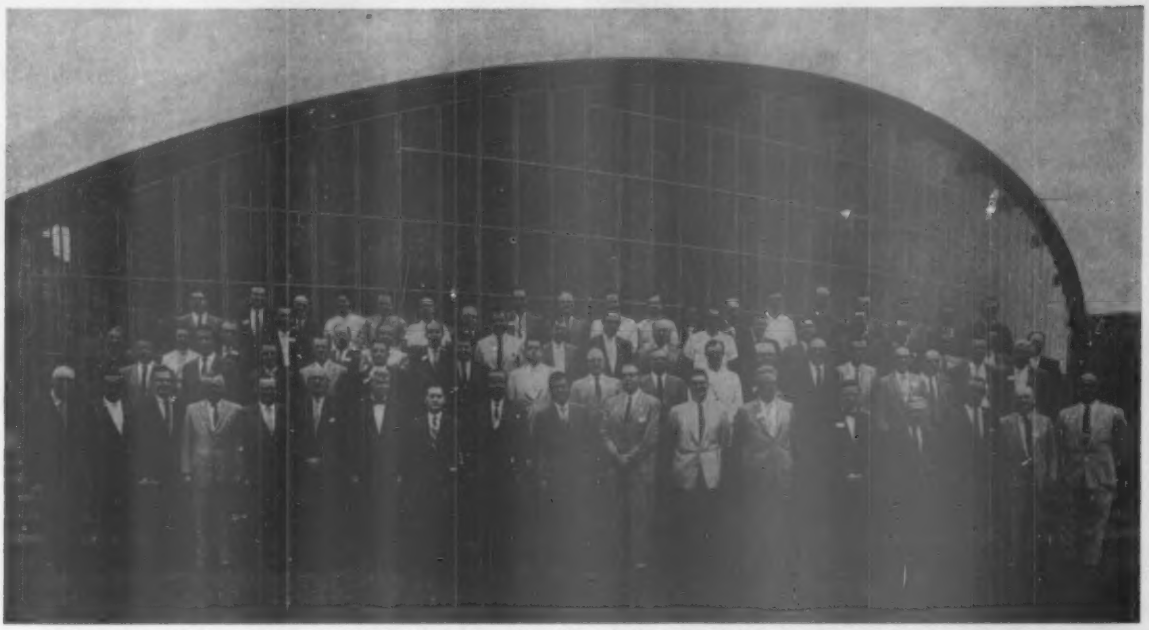
Peas exposed experimentally were mixed daily. One would expect that if they had remained undisturbed, color changes would have been observed in shorter periods. Color changes were confined mostly to the seed coat. Thus, only the surfaces receiving illumination would be involved, but the resulting mottled appearance would be as unattractive as a uniformly discolored product.

Alteration of chlorophyll was involved in the color changes. Whether conversion to pheophytin is the only, or even the principal, alteration was not determined. Measurements were made of the percentage conversion to pheophytin because it is a convenient and established procedure.

Frost formation is more rapid in packages subjected to illumination than in those stored in the dark. Effect of this factor on acceptability is not known.

ALLAN D. SHEPHERD
Western Utilization Research and Development Division
Agricultural Research Service
U. S. Department of Agriculture
Albany 10, California

April 14, 1959.



Represented at the Symposium were FDA officials including Commissioner Larrick, university, industry, association, government and Armed Forces representatives.

Food Additives Amendments Analyzed

A one-week symposium on Food Protection Factors in Modern Food Technology was held at M.I.T. during the week of June 22, 1959, under the auspices of the Department of Food Technology, M.I.T.

Key personnel from the Food and Drug Administration, the Meat Inspection Division of the Department of Agriculture, from various industrial organizations, together with members of the M.I.T. Department of Food Technology analyzed the 1958 Food Additive amendment in relation to: administration, legal principles and rule-making, the mechanics of toxicology and testing, radiological contamination of the food supply, and radiation preservation. Representatives from several food industries discussed the amendment in relation to their own activities.

The significant amount of give-and-take between participants and listeners resulted in a profitable and enjoyable experience. Speakers included:

Dr. B. E. Proctor	Mr. Paul M. Jacobs
Mr. Ray B. Wakefield	Dr. Richard L. Hall
Dr. John F. Mahoney	Mr. Arthur T. Schramm
Mr. H. R. Hinton	Dr. H. L. Janovsky
Dr. Ira I. Somers	Dr. S. A. Goldblith
Dr. Berton S. Clark	Dr. C. H. Pals
Dr. Philip K. Bates	Dr. Daniel DeCamp
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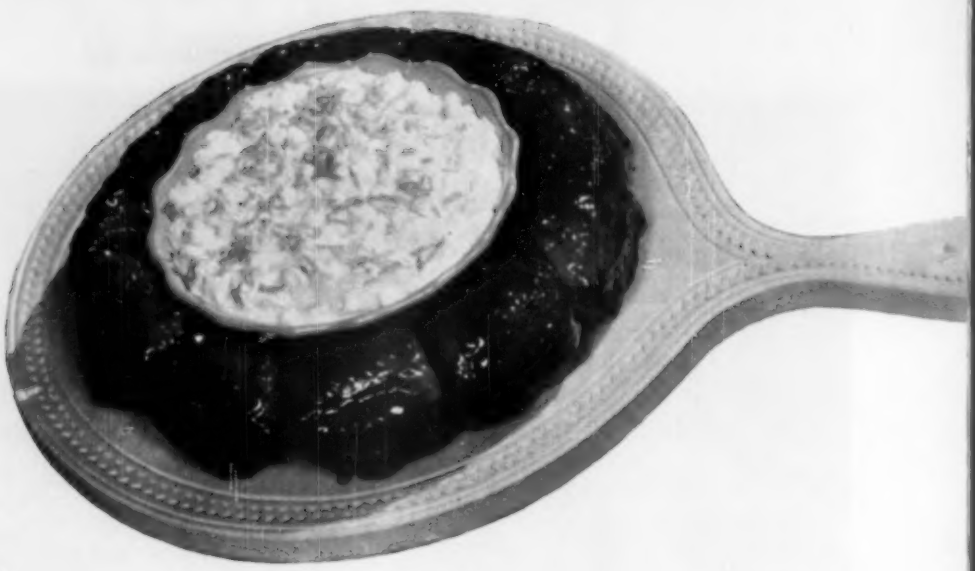

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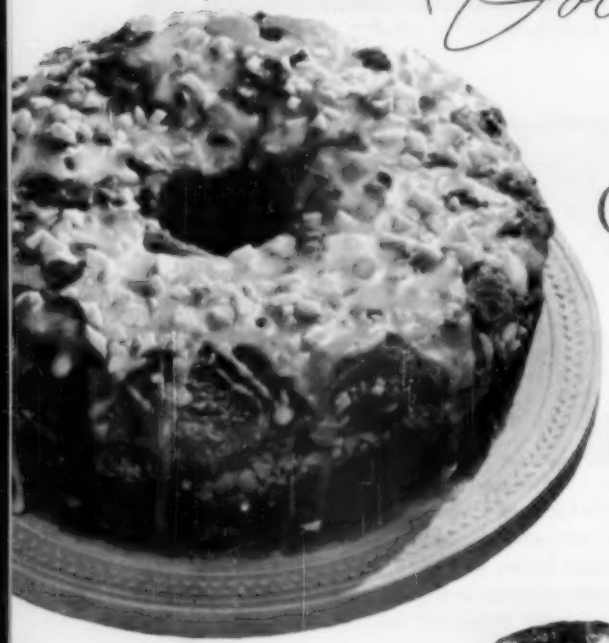

Photograph courtesy of The Family Circle, Inc.

REGIONAL NEWS

MEXICO

On Thursday, the 9th of July, at 8 P. M., a most enjoyable supper at "La Flor de Lis" located at Huichapan No. 21, was given in honor of our colleague, Tech. Chem. Rafael Illescas Frisbie, who has been named General Director of Foods and Beverages of the Secretariat of Health and Assistance.

The Mexico Section is most pleased by the distinction that has been conferred on Señor Frisbie.

—Emma Guillermina Balboa M.

WISCONSIN

The Spring activities of the Wisconsin Section began with a meeting on March 20, 1959 at Milwaukee. Sixty members and guests enjoyed a tour of the Chain Belt Company with special emphasis on the dehydrating equipment manufactured by the firm. Following dinner, Mr. Gerald Bard of Chain Belt presented an excellent discussion of "Modern Methods of Dehydration as Applied to the Food Industry."

On April 24th, the section met at the Abbott Laboratories, North Chicago, Illinois. Ninety members and guests, including a number from the Chicago section, toured the Abbott research and development facilities. After an excellent dinner at the Abbott cafeteria, Dr. W. E. Grundy of the Abbott staff spoke on a very timely and interesting subject, "Antibiotics in Foods."

The Spring meetings of the Section were culminated with Career Day on May 29. Twenty-three high school seniors representing 15 different cities throughout Wisconsin were guests at the affair. Speakers at the afternoon session, which was devoted to acquainting the guests with the career potential of the food industry, included

V. E. Kivlin—Assoc. Dean of the College of Agriculture

M. A. Schaars—Professor of Agri. Economics

A. C. Rice—Assoc. Professor of Dairy and Food Industries

K. G. Weckel—Professor of Dairy and Food Industries

E. M. Foster—Professor of Bacteriology

W. H. Gabelman—Assoc. Professor of Horticulture

D. J. Hagedorn—Professor of Agronomy and Plant Pathology

J. W. Apply—Professor of Entomology

K. C. Berger—Professor of Soils

R. W. Bray—Professor of Animal Husbandry

M. L. Sunde—Professor of Poultry Husbandry

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Interspersed with the speakers were tours of the Food Technology teaching and research facilities at Babcock Hall and the new bacteriology building. Ray Wakefield, Gerber Foods Company and President of the IFT gave the closing address of the afternoon session, "Horizons in the Food Industry."

Following dinner, the section heard an excellent discussion of "Breakfast Cereals, their role in human nutrition and problems in their production" by Paul Salo of General Mills. A very interesting and enjoyable experience was had by everyone attending the first of what we hope to be a continuing series of annual "Career Day" sessions.

MARYLAND

The Section held its monthly meeting at the Stafford Hotel in Baltimore on Friday, June 19, 1959. Free beer and door prizes were graciously furnished with the compliments of Continental Can Company. Miss Barbara Hall, Home Economist for Continental Can Company Metal Research and Development, gave an illustrated lecture on "Some Applications of A New Flavor Testing Technique." Miss Hall's talk was very informative and an interesting question and answer period followed. About 35 members and guests were present.

CHICAGO

The 1959 Chicago Section membership Directory, in which is included the Section By-Laws, is off the press and in the hands of the members. For preparing the copy and for the attractive cover, special thanks go to Mrs. Anna May Schenck. The Directory Committee was headed by B. J. McKerman (Armour) with Margaret Ives (American Can Company), R. D. Trelease (Swift), R. B. Davis (Continental Can Company), and Anna May (Continental Can Company) as members. Consulting the section listing the companies and institutions with IFT members on their staffs, one finds that some 280 organizations of the Chicago and surrounding area are represented in the Directory. Seven of these organizations are represented by 20 to 40 IFT members each. The Section has well over 600 members as of this date (August, 1959).

Mr. Warren E. Jones, Consultant and Partner, Management Controls, Inc., spoke on statistical quality control applications in the food industry at the May Meeting of the Chicago Section.

Statistical quality control was reported to be the sharpest new tool in half a century. Many food manufacturers are looking to statistical quality control to solve many of their problems. Mr. Jones stated it could only be a solution to part of the problems, and then only if wisely used and correctly interpreted.

One of the simplest setups, he said, was one in which you select a series of possible defects and designate them as either major or minor and then set per-

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centage standards of each which you were willing to tolerate in the finished product. Mr. Jones undertook an explanation of some elementary inspection procedures and inspection philosophies such as the introduction of tightened inspection at the start of any process, followed by reduced inspection as a second step after the process performs satisfactorily for a period of time. The requirements for good quality control were given as: 1) high volume; 2) automatic process and 3) high dollar value.

Mr. Jones described the ideal relationship between setting up quality control standards and product development, from research through production. He felt quality control measures could be introduced after approximately 20 batches or 2 or 3 weeks of production. Research could then withdraw after 20, 30 or 40-trouble-free batches had been produced. He carefully emphasized the word 'trouble-free' might mean several hundred batches of production before research could withdraw and leave the field entirely to quality control.

Mr. Jones also discussed some economical factors involved in quality control, such as the cost to introduce a system and the cost to maintain an effective system, but specific evaluations are dependent on the exact nature of the operation.

Saturday, September 26, at the University of Wisconsin—those are the bare facts on the first meeting of the fall season. But as guests of the Wisconsin Section there is a tour of the Department of Dairy and Food Industries, a luncheon, and the Wisconsin-Stanford football game.

Literature

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY[a]

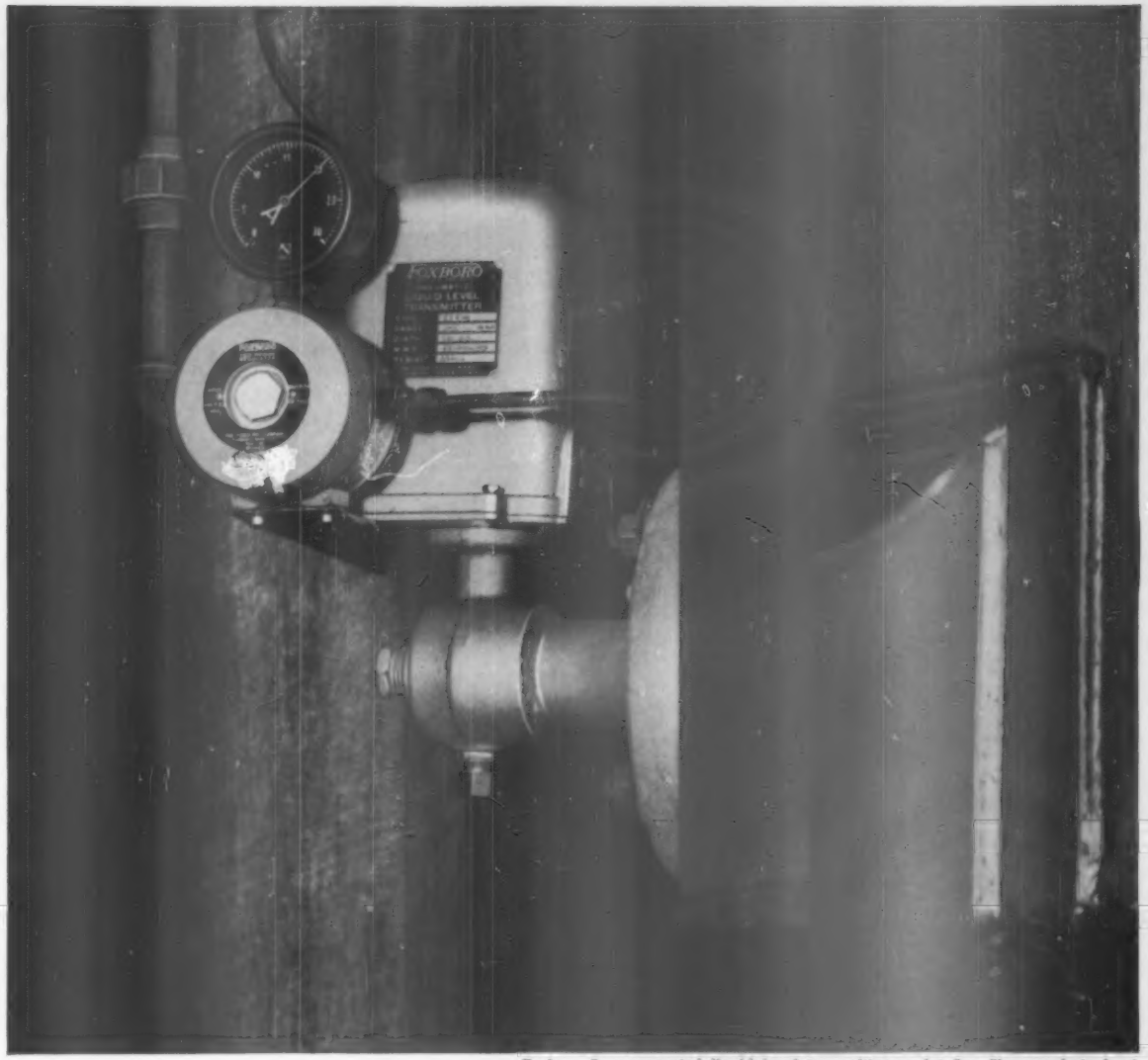
Commodities

Encyclopedia of candy and ice-cream making. Simon I. Leon. New York, Chemical Publishing Co., 1959. 454 p. $12.00. A true encyclopedia arranged in alphabetical order covering all phases of the industry with a great many formulas.

Manufacture and analysis of carbonated beverages. Morris B. Jacobs. New York, Chemical Publishing Co., 1959. 333 p. $11.00. Covers raw materials, manufacturing processes, and control of the finished product.

National grain policies. Rome, Food and Agriculture Organization, 1959. 108 p. pap. Factual information of national policies and measures affecting grains, for 21 countries.

[a] Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 West Pershing Road, Chicago 9, Illinois.



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Okra for processing. J. G. Woodroof and Ethyl Shelor. Athens, Ga., 1958. 51 p. (Georgia. Agricultural Experiment Stations. Bulletin, n.s. 56.) pap. apply.

Proceedings of the Seventh Annual National Dairy Engineering Conference. East Lansing, Mich., Department of Agricultural Engineering, Michigan State University, 1959. 105 p. processed. $2.00. Another in the series which covers problems from the farm through the commercial plant.

Proceedings of the 28th annual State College of Washington Institute of Dairying. Pullman, Wash., Department of Dairy Science, W.S.C., 1959. 131 p. processed. Papers presented at the Institute.

Production yearbook, 1958. Rome, Food and Agriculture Organization, 1959. 475 p. Vol. 12 of the annual series on agriculture and food production.

Salting peanuts in the shell for roasting. S. R. Cecil and J. G. Woodroof. Athens, Ga., 1959. 4 p. processed. (Georgia. Agricultural Experiment Stations. Mimeographed series n.s. 68.) Revision of a process first published in Food Engineering, November 1952.

Whole kernel sweet corn for canning and freezing. Wilbur A. Gould and others. Wooster, Ohio, 1959. 72 p. (Ohio Agricultural Experiment Station. Research bulletin 826.) No. 4 in a series on fresh and processed vegetables.

Food Technology

Chemistry and technology of cereals as food and feed. Samuel A. Matz, ed. Westport, Conn., Avi Publishing Co., 1959. 732 p. $15.00. An outstanding list of writers have prepared the various chapters. Editor was formerly Chief, Cereal and General Products Branch, Food Division, Quartermaster Food and Container Institute. A review of this book will appear in a subsequent issue of FOOD TECHNOLOGY.

Food-packaging materials; their composition and uses; a report of the Food Protection Committee, Food and Nutrition Board. Washington, National Research Council, 1958. 48 p. (National Research Council. Publication 645.) pap. $1.00.

Frozen food pack statistics, 1958. Washington, D. C. National Association of Frozen Food Packers, 1959. 2 v. pap. apply. Part 1 is Fruit, and pt. 2, vegetables.

Pressurized packaging (aerosols). A. Herzka and J. Pickthall. Academic Press, Inc. New York. 1959. 411 p. $12.00.

Procedures for the testing of intentional food additives to establish their safety for use. Second report of the Joint

(Continued on page 30)

PROCTOR

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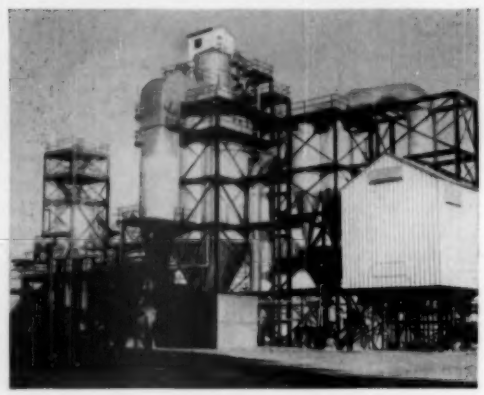

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FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

September 13-18	136th National Meeting of the American Chemical Society, Atlantic City, New Jersey
September 22	Instrument Society of America 14th Annual Meeting. Symposium and Workshop for Management People, Engineers and Technologists in the Food Industry, Chicago, Illinois
September 22-24	Institute of Sanitation Management, Annual Conference and Show, Hotel New Yorker and New York Trade Show Building
September 22-24	Third Annual Industrial Nuclear Technology Conference, Morrison Hotel, Chicago Illinois
September 24-25	American Society of Quality Control, Third Annual Chemical Division Technical Conference, The Shamrock Hilton Hotel, Houston, Texas
September 28-30	American Oil Chemists' Society Fall Meeting, Statler Hilton Hotel, Los Angeles, California
October 7-9	Sixth National Symposium on Vacuum Technology of the American Vacuum Society, Sheraton Hotel, Philadelphia
October 12-14	Association of Official Agricultural Chemists, Shoreham Hotel, Washington, D. C.
October 23	12th Annual Conference, Southern California Section, IFT, and Nutrition Foundation, Inc. Miramar Hotel, Santa Monica, California. Theme: Current Trends in Food and Nutrition
November 4-6	Sectional Meeting of the Society for Applied Spectroscopy and Instrument Exhibition, Hotel New Yorker
November 16-18	Annual National Packaging Forum of the Packaging Institute, Inc., Hotel Statler, New York, N. Y.
1959-1960	
December 26-January 3	Dairy and Food Exposition, New York Coliseum, New York, N. Y.
1960	
May 15-19	**Twentieth Annual Meeting of the Institute of Food Technologists, Fairmont Hotel and Masonic Temple, San Francisco, California**
1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17-20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbor, Miami Beach, Florida**

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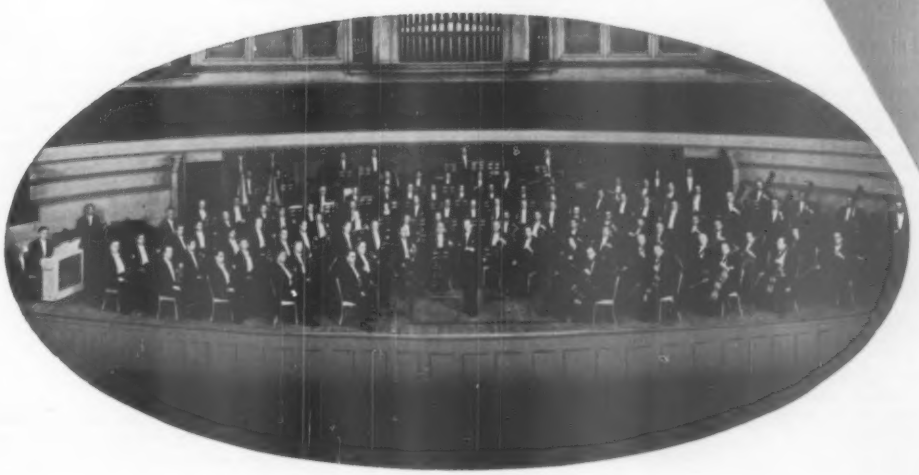

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FAO/WHO Expert Committee on Food Additives. Rome, Food and Agriculture Organization, 1958. 19 p. (FAO Nutrition Meetings report series no. 17.) pap. $0.30. Also obtainable from Columbia University Press, International Documents Service.

Research on the refrigeration of perishable commodities. Annual report of the Director, 1958. Colorado Springs, Colo., Refrigeration Research Foundation, 1959. 44 p. pap. apply. Summaries of work in progress and the resulting publications.

Specifications for identity and purity of food additives. Third report of the Joint FAO/WHO Expert Committee on Food Additives. Rome, Food and Agriculture Organization, 1959. var. p. mimeographed. (FAO/59/3/2140.) A preliminary edition, not yet approved by the Executive Board of WHO, which sets out the details of tests and specifications.

Viewpoints on food additives. Symposium presented before 134th annual meeting of the Division of Chemical Marketing and Economics (ACS) September 11, 1958. Chicago.

Nutrition

Food values in shares and weights in common servings with suggestions for personal food needs; 2nd ed. Clara Mae Taylor. New York, Macmillan, 1959. 126 p. $4.00. First edition published in 1942, now thoroughly revised.

Joint FAO/WHO Expert Committee on Nutrition. Fifth report. Rome, Food and Agriculture Administration, 1958. 55 p. (FAO Nutrition Meetings report series no. 19.)

Proteins in foods. S. Kuppuswamy, M. Srinivasan, and V. Subrahmanyan. New Delhi, India, Indian Council of Medical Research, 1958. 289 p. (Special report series no. 33.) Short text to each chapter, but detailed tables and a considerable bibliography.

Report of the FAO Nutrition Meeting for Europe, Rome, 1958. Rome, Food and Agriculture Organization, 1958. 28 p. (FAO Nutrition Meeting series no. 21.) pap. $0.50. Also obtainable from Columbia University Press.

Report of the FAO/UNICEF regional school feeding seminar for Asia and the Far East. Tokyo, Japan, 10–19 Nov. 1958. Rome, Food and Agriculture Organization, 1959. 52 p. pap. (FAO nutrition meetings report series, no. 22.)

Sucre et montagne: I ere partie: Travail et alimentation en haute altitude. G. Le Bideau, et Mme. Berard. Paris, Documentation Scientifique du Cedus, 1959(?) 26 p. pap. A summary of the literature.

Biological Aspects

Microbiology; 2nd ed. Louis P. Gebhardt and Dean A. Anderson. St. Louis, C. V. Mosby, 1959. 476 p.

Chemical Aspects

Advances in inorganic chemistry and radio chemistry, v. 1. H. J. Emeléus and A. G. Sharpe, eds. New York, Academic Press, 1959. 460 p. $12.00. A new title in the "Advances" group.

Advances in protein chemistry, v. 13. C. B. Anfinsen, jr. and others. ed. New York, Academic Press, 1958. 535 p. $13.80. Continues a long useful series.

Colorimetric determination of nonmetals. David F. Boltz, ed. New York, Interscience, 1958. 372 p. (Chemical analysis v. 8.)

Diagnostic biochemistry; quantitative distribution of body constituents and their physiological interpretation. Halvor N. Christensen. New York, Oxford University Press, 1959. 300 p. For analysis in the clinical laboratory, but with somewhat wider usefulness.

Industrial fatty acids and their applications. E. Scott Pattison, ed. New York, Reinhold, 1959. 230 p. $7.00. Articles by authorities on the production and processing of fatty acids.

Bibliographies

Food preservation by irradiation, 1951–58. Washington, D. C., 1959. 4 p. (U. S. Dept. of Commerce. Office of Technical Services. Catalog of technical reports. CTR 357.) pap. $0.10. Includes entries for a great many final reports from the Quartermaster Food and Container Institute with an indication of their cost when secured through OTS.

Miscellaneous

Dictionary of nuclear science and technology. W. E. Clason. Princeton, N. J. D. Van Nostrand, 1958. 914 p. $25.00. In English, American, French, Spanish, Italian, Dutch and German. Useful for those working on the radiation of foods.

Flow measurement and control. Wilfred F. Coxon. New York, Macmillan, 1959. 322 p. (Physical processes in the chemical industry, v. 3.) $11.00. An imported reference book for chemical engineers and students describing apparatus used.

National food reserve policies in underdeveloped countries. Rome, Food and Agriculture Organization, 1958. 70 p. FAO Commodity policy studies, 11.) pap. $1.00. Also obtainable from the Columbia University Press.

Performance data on a new ionization detector. L. V. Guild, M. I. Lloyd, and F. Aul. Pittsburgh, 19, Pa., Burrell Corp., 1959. 21 p. processed. Presented at the Instrument Society of America, 2nd International Symposium on Gas Chromatography, East Lansing, Mich., June 10, 1959.

State of food and agriculture for 1958. Rome, Food and Agriculture Organization, 1958. 222 p. pap. $2.50. Also obtainable from the Columbia University Press.

The food trade directory of trade marks and brand names. London. Food Trade Review Ltd. 1959.

ABSTRACTS

General Foods Research Center
Selected by H. A. Campbell

ANALYTICAL METHODS

Cloud point as a means of characterizing the polyglycols of polyoxyethylene (8) stearate.

Brewster, M. D. and Brandner, J. D. (Atlas Powder Co., Wilmington, Del.). *J. Agr. Food Chem.* 7, 348–9 (1959).

Polyoxyethylene (8) stearate which has been used extensively in yeast-raised baked goods may be characterized by the cloud point of the recovered polyethylene glycols. This test is sensitive to the mol. wt. distribution of the polyglycols in the mixt. and hence will distinguish between polyethylene glycols which have a Poisson-type distribution and those of the same average mol. wt. but having a nonrandom distribution of polyethylene glycols. Cloud point is particularly sensitive to the presence of polyethylene glycols of mol. wt. greater than 600.

The determination of egg in certain foods by enzymic hydrolysis of the phospholipids.

Casson, C. B. and Griffin, F. J. (J. Lyons & Co. Ltd., London, Engl.). *Analyst 84,* 281–6 (1959).

A method is described for the detn. of egg solids in foods; hydrolysis of the phospholipids is effected by means of the enzyme lecithinase D. The liberated choline is sepd. by adsorption on a cation-exchange resin and, after elution, is detd. colorimetrically as the reineckate. The application of the method to the detn. of egg solids in salad cream is dealt with.

BIOLOGICAL SCIENCES

Biochemistry

Biochemistry of erythorbic acid. Human blood levels and urinary excretion of ascorbic and erythorbic acid.

KADIN, H. AND OSADCA, M. (General Foods Research Center, Tarrytown, N. Y.) *J. Agr. Food Chem. 7*, 358–60 (1959).

Comparative blood level trials in five normal subjects showed that the ingestion of erythorbic acid which has less than 1% of the vitamin C activity of L-ascorbic in animals, can lead to overestn. of the state of vitamin C nutrition as judged by blood levels. A rapid, quant. paper chromatographic technique for sepn. of the isomers showed no significant displacement of L-ascorbic by 300-mg. doses of erythorbic acid.

Tissue sulfhydryl groups.

ELLMAN, G. L. (Dow Chem. Co., Midland, Mich.). *Arch. Biochem. Biophys. 82*, 70–7 (1959).

A water-soluble (at pH 8) aromatic disulfide [5,5-dithiobis(2-nitrobenzoic acid)] has been synthesized and shown to be useful for detn. of sulfhydryl groups. Several applications have been made to show its usefulness for biological materials.

Sulfur amino acid requirement for lactation in the rat.

NELSON, M. M. AND EVANS, H. M. (Univ. of Calif., Berkeley). *Proc. Soc. Exptl. Biol. Med. 100*, 723–5 (1959).

Supplementation of 12, 18, and 24% casein diets with 0.5% L-cystine markedly improved lactation performance as judged by weaning weights of young and mother. The data indicate that total sulfur amino acid requirement for optimal lactation in the Long-Evans rat may be placed at slightly more than 1% of the diet and that cystine may furnish at least half of this requirement.

Site of reaction of wax bean hemagglutinin with rabbit erythrocytes.

NORTHROP, R. L. AND LIENER, I. E. (Univ. of Minnesota, St. Paul). *Proc. Soc. Exptl. Biol. Med. 100*, 105–8 (1959).

Many plant seeds contain substances which agglutinate animal erythrocytes. Experiments reported here reveal several features of rabbit erythrocyte agglutination common to wax bean hemagglutinin and to influenza and Newcastle Disease viruses. This suggests that both may act on the same site of the red cell membrane.

Toxic protein degradation products.

RINDERKNECHT, H. AND NIEMANN, C. (California Inst. of Technol., Pasadena). *Proc. Soc. Exptl. Biol. Med. 100*, 35–40 (1959).

Toxic polypeptides, prepd. by treatment of certain proteins with boiling 2% ethanolic sodium hydroxide, have been characterized. The most toxic prepns. obtained by a salting out procedure, fol-

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lowed by dialysis or by ion exchange chromatography, while non-toxic when given orally, were lethal to guinea pigs at a level of 0.5 mg./kg. intravenously.

Decreasing "amino acid hunger" of human muscle with age.

CHRISTENSEN, H. N., THOMPSON, D. H., et al. (Univ. of Michigan Med. School, Ann Arbor). *Proc. Soc. Exptl. Biol. Med. 100*, 780–2 (1959).

Injected C_1^{14} α-aminoisobutyric acid was much more strongly coned. by skeletal muscle in children than in men. The greater general uptake by tissues could be recognized by the resultant consistently lower plasma level in the young. The absence of catabolism of this amino acid was shown by observation of less than 0.002% of the injected C^{14} in expired air during 6 hours, counting respiratory CO_2 in the form of Li_2CO_3.

Incorporation of C^{14}-amino acids into protein of isolated diaphragms: an effect of insulin independent of glucose entry.

WOOL, I. G. AND KRAHL, M. E. (Univ. of Chicago, Ill.). *Am. J. Physiol. 196*, 961–4 (1959).

The effect of glucose concn. and insulin on protein synthesis was investigated using the isolated rat diaphragm and C^{14}-labeled amino acids. When the donor rat has been well fed, the incorporation of histidine-2-C^{14}, lysine-2-C^{14}, phenylalanine-3-C^{14}, and alanine-1-C^{14} into muscle protein is uninfluenced by glucose concn. in the medium over the range 0–600 mg. %. Insulin leads to an increase in C^{14}-amino acid incorporation into muscle protein in the absence of glucose in the medium. These findings suggest an effect of insulin on protein metabolism independent of its action in promoting glucose entry.

Amino acid and glucose uptake in relation to protein synthesis in cells growing in tissue culture.

SINCLAIR, R. AND LESLIE, I. (Queen's Univ., Belfast, Ireland). *Biochim. et Biophys. Acta 32*, 58–68 (1959).

Replicate roller tube cultures of short-term human fetal lung and kidney cells, of a transformed human liver cell strain and of long-term human malignant strains have been used to investigate amino acid uptake, protein synthesis and carbohydrate metabolism during cell multiplication in growth-promoting medium. The uptake of 13 individual amino acids has been followed by quant. paper chromatography.

Microbiology

Agarase from an agar-digesting bacterium.

SWARTZ, M. N. AND GORDON, N. (Massachusetts General Hosp., Boston). *J. Bacteriol. 77*, 403–9 (1959).

A versatile agarbacterium has been described which grows on various oligo- and polysaccharides and adaptively forms enzymes which will cleave these carbohydrates. An enzyme, agarase, has been purified about 10-fold from the culture medium and appears to release oligosaccharide units, but not free galactose, from agar. Further breakdown of these oligosaccharides may be carried out by other enzymes in the medium or in the bacterium itself. These adaptively formed enzymes in the agarbacterium may provide helpful tools in studying the structure of some of the naturally occurring polysaccharides.

A study of frozen precooked foods: Their sanitary quality and microbiological standards for control.

ABRAHAMSON, A. E., BUCHBINDER, L., et al. (Dept. of Health, City of New York). *Assoc. of Food & Drug Offic. U.S. Quart. Bull. 23*, 63–72 (1959).

In the City of New York a microbiological study was made of 195 samples of frozen precooked foods of nationally known brands, obtained at the retail level. At this level about 76% (including poultry products which conform to the extent of 54%) were found to meet the Department of Health criteria of less than 100,000 colonies/g. and no *Staphylococcus aureus*.

Nutrition

Evaluation of protein in foods. I. A method for the determination of protein efficiency ratios.

CHAPMAN, D. G., CASTILLO, R. AND CAMPBELL, J. A. (Dept. of Natl. Health and Welfare, Ottawa, Can.). *Can. J. Biochem. Physiol. 37*, 679–86 (1959).

This bioassay method involves measurement of the protein efficiency ratio (grams gain per gram protein consumed) under standardized conditions. Male rats of the Wistar strain 20–23 days of age are fed *ad libitum* an otherwise adequate reference diet contg. 10% protein supplied by a standard sample of casein. Foods to be assayed are added to the diet as the sole source of protein at the expense of the casein and corn starch to maintain a protein level of 10%. Protein efficiency ratios (P.E.R.'s) are calcd. after 4 weeks and are adjusted to a const. value of 2.5 for casein. Although influenced by the age of rat and subject to certain inherent criticisms, detn. of P.E.R. values was found to be a simpler method for evaluating protein quality than detn. of net protein retention or net protein utilization and equally sensitive.

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Studies on the role of enzyme supplements and water treatment for improving the nutritional value of barley.

WILLINGHAM, H. E., JENSEN, L. S. AND MCGINNIS, J. *Poultry Sci. 38*, 539–44 (1959).

A highly significant improvement in growth and feed utilization of chicks occurred when diets contg. barley were supplemented with enzymes from bacterial and fungal sources and malted barley. However, cryst. amylase was completely inactive.

The utilization by the chick of protein bound as compared to free dietary lysine.

SCHWARTZ, H. G., TAYLOR, H. G. AND FISHER, H. (State Univ., New Brunswick, N. J.). *Poultry Sci. 38*, 316–18 (1959).

The present investigation has not detected any difference in the utilization of lysine by chicks whether added in the free form or as part of the protein structure.

An adequate diet.

MAYNARD, L. A. (Cornell Univ., Ithaca, N. Y.). *J. Am. Med. Assoc. 170*, 457–8 (1959).

An adequate diet is one which meets in full all the nutritional needs of the person. These needs are set forth for infants, children, boys, girls, men and women in the report entitled Recommended Dietary Allowances. A very helpful guide for food selection is Essentials of an Adequate Diet, Home Economics Research Report 3, Agr. Research Service, 1957. In this publication, foods are divided into 4 groups, and directions are given as how to choose a diet from these groups.

Dietary treatment of an infant with phenylketonuria.

BRIMBLECOMBE, F. S., STONEMAN, M. E. AND MALIPHANT, R. *Lancet 7073*, 609–11 (1959).

Normal intelligence was apparently regained and maintained in a child with phenylketonuria, in whom dietary treatment was started at the age of 17 weeks. The evidence suggests that treatment must be started at a very early age if the rate of mental development is to be notably enhanced. All infants should have their urine tested for phenylketones at the age of 3 weeks, and possibly again at 6 weeks.

Hyperbilirubinemia of newborn infants associated with the parenteral administration of a vitamin K analogue to the mothers.

LUCEY, J. F. AND DOLAN, R. G. (Univ. of Vermont Coll. of Med., Burlington). *Pediatrics 23*, 553–60 (1959).

Seven cases of marked hyperbilirubinemia occurring among premature infants within the first 40 to 72 hrs. of life are reported. The mothers of these infants had received 72 mg. of a vitamin K analogue intramuscularly or intravenously from 2 to 112 hrs. prior to delivery. The hypothesis is presented that the vitamin K analogue passed through the placenta and exerted a hepatotoxic effect upon the newborn infant. Because of possible serious consequences to the infant, new drugs should be used with caution when administered to pregnant women or to newborn infants.

X. Endogenous dilution of administered labeled acetate during lipogenesis and cholesterogenesis in two types of obese mice.

ZOMZELY, C. AND MAYER, J. (Harvard School of Public Health, Boston, Mass.). *Am. J. Physiol. 196*, 956–60 (1959).

Determination of diln. of administered labeled acetate by endogenously produced acetate in 2 types of obese mice: goldthioglucose obese mice (regulatory obesity) and obese hyperglycemic mice (metabolic obesity) shows that this diln. is of the same order for obese and nonobese mice when fed ad libitum. These data in conjunction with results obtained on incorporation of C^{14} into fatty acids and cholesterol show that the increased synthesis of these lipids is related solely to the hyperphagia in the case of the goldthioglucose obese mice. The results justify the previously drawn distinction between 'regulatory' and 'metabolic' obesities.

The nutritional effect of polymers isolated from thermally oxidized corn oil.

PERKINS, E. G. AND KUMMEROW, F. A. (Univ. of Illinois, Urbana). *J. Nutrition 68*, 101–8 (1959).

Weanling rats were fed for 21 days a diet composed of 50% glucose, 31% casein, 5% Wesson salt, 2% fresh cottonseed oil, 12% of the test fat or fatty acid fraction, and all of the known required water- and fat-soluble vitamins. Those fed the non-distillable residue from the non-urea-adduct-forming fatty acids of corn oil which had been heated at 200° C. for 48 hrs. and represented approximately 30% of the original oil all died within 7 days. Although the fatty acids from thermally oxidized oil depressed growth significantly, the rats fed the urea-adduct-forming fatty acids, which represented 64% of the oil, gained as much wt. as those on the fatty acids of fresh corn oil.

Biological and chemical studies on commercial frying oils.

KEANE, K. W., JACOBSON, G. A. AND KRIEGER, C. H. (Campbell Soup Co.,

Camden, N. J.). *J. Nutrition 68*, 57–74 (1959).

Hydrogenated cottonseed oil heated in a commercial deep-fat fryer under actual production conditions for as long as 24 days had no deleterious effects on rats when fed at levels as high as 20% of the diet. A highly significant positive correlation was found to exist between the nutritive value of the fat as measured by the caloric restriction technique, and the total non-conjugated double bonds present in the fat. Fats which have been heated and oxidized under laboratory conditions yield a lower growth rate in rats than the unheated oils but exhibit no apparent symptoms of toxicity (i.e., diarrhea, rough hair coat, etc.) when tested using nutritionally adequate diets.

Cod-liver oil as both source and antagonist of vitamin E.

Moore, T., Sharman, I. M. and Ward, R. J. (Univ. of Cambridge, Engl.). *Brit. J. Nutrition 13*, 100–10 (1959).

By chemical methods a specimen of medicinal cod-liver oil was found to contain about 10 mg. α-tocopherol/100 g. In rats given a diet with 10% of cod-liver oil all the abnormalities caused by avitaminosis E could be prevented by an adequate weekly dose of DL-α-tocopheryl acetate. The failure of whole cod-liver oil to act as a good source of vitamin E in accordance with the results of chemical tests may therefore be explained by the antagonistic action of its other components, particularly its highly unsatd. fatty acids.

Study of vitamin E supplements in relation to muscular dystrophy and other diseases in aging rats.

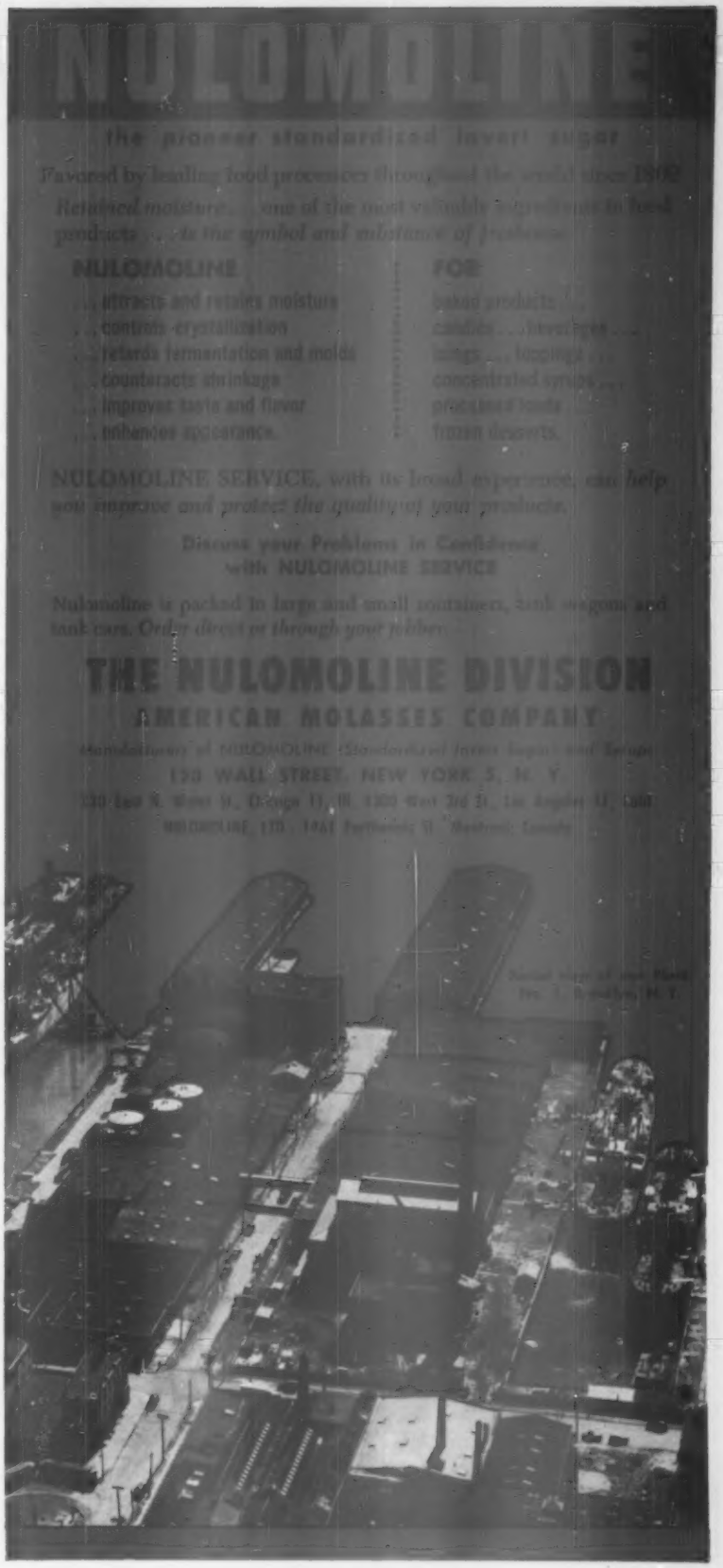
Berg, B. N. (Columbia Univ., New York City). *J. Gerontol. 14*, 174–80 (1959).

Large supplements of α-tocopherol failed to prevent the muscular dystrophy of aging rats. Other chronic diseases, longevity, and growth were also unaffected.

Nutritional factors in liver disease in man.

Leevy, C. M. (Natl. Insts. of Health, Bethesda, Md.). *Am. J. Clin. Nutrition 7*, 146–60 (1959).

Utilizing serial liver biopsies in man, it is possible to demonstrate a transition of fatty liver to cirrhosis and eventual development of hepatoma in malnourished alcoholic subjects. The frequent occurrence of this sequence makes it desirable to consider fatty liver as the first stage of cirrhosis, as early recognition and treatment with an adequate diet prevents development of cirrhosis and its complications. 39 references.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General physiology of aging.

GROEN, J. J. (Hadassah Univ., Jerusalem, Israel). *Geriatrics 14*, 318–32 (1959).

The process of aging is a combination of biologic and physiologic changes, varying in nature and intensity with the individual. Such factors as biochemical processes, decreased sexual function, increased incidence and severity of disease, and adjustment to physical and environmental changes are discussed.

Toxicology

Biochemical and pharmacological aspects of colors and flavors.

WILLIAMS, R. T. (St. Mary's Hosp. Med. School, London, Engl.). *Chem. & Ind.* 473–6 (1959).

The physiological actions of sulfonic acids, azo dyes, and a number of esters, alcohols, aldehydes, phenols and lactones used in the food industry as coloring and flavoring agents are briefly reviewed.

Gamma-aminobutyric acid.

ELLIOTT, K. A. AND JASPER, H. H. McGill Univ., Montreal, Can.). *Physiol. Revs. 39*, 383–406 (1959).

Current interest in γ-aminobutyric acid (GABA) has arisen from the demonstration that this compd. has an important physiological action upon brain function and certain peripheral nervous structures. This review discusses the relationship of GABA and similar substances to the possible mechanisms underlying disturbances in brain metabolism, which form the basis for certain mental diseases.

ENGINEERING RESEARCH

New types of galvanic fuel cells.

STRAATMAN, J. F. *Brit. Chem. Eng. 4*, 286–8 (1959).

Galvanic fuel cells are electric cells which derive their energy from a reaction taking place in one of 2 reactant streams which continually pass through the cell. Usually the reactants are gaseous. For example a reducing stream of H_2 passing through the anode is partly converted to water by oxygen transferred through the cell electrolyte from an oxygen stream passing through the cathode. The efficiency of energy conversion to electricity is very high, 65% or even up to 80%. There are cells for ambient temp. operation, the Natl. Carbon Co. cell, but the more efficient ones operate at temps. about 720° C., the Davtyan and the Broers cells.

The engineer's bookshelf.

KOFF, R. M. *Product Eng. 30*, 45–60 (Mar. 30, 1959).

A detailed compilation of periodicals, indexes, handbooks, general library references and books published within the last 2 years, arranged in broad subject classifications for the design engineer.

FOOD AND FOOD TECHNOLOGY

Antioxidants

A direct spectrophotometric determination of butylated hydroxyanisole in lard and hardened lard.

HANSEN, P. V., KAUFFMAN, F. L. AND WIEDERMAN, L. H. (Swift and Co., Chicago, Ill.). *J. Am. Oil Chemists' Soc. 36*, 193–5 (1959).

A direct spectrophotometric method for the detn. of butylated hydroxyanisole has been presented. This procedure allows good precision in the analysis of lard and hardened lard contg. from 0 to 100 p.p.m. of BHA and is more reliable than existing colorimetric techniques, especially in the lower range of antioxidant concns.

Antioxidant effect in boxboard.

CALDWELL, E. F. AND SHMIGELSKY, S. *Modern Packaging 32*, 111–13 (May 1959).

Inside surface of double-bleached manila lined clipboard was sprayed by a board manufacturer with butylated hydroxyanisole in an amt. equal to .05% of board by weight. Stored samples of wheat flakes, corn flakes and rice flakes in one ounce size cartons made from the treated board resulted in significant improvement in organoleptic acceptability.

Gelatin

Isolation of gelatin from ancient bones.

SINEX, F. M. AND FARIS, B. (Boston Univ. School of Med., Mass.). *Science 129*, 969 (1959).

The isolation and characterization of gelatin from 12,000-year-old deer antlers is described. Use of gelatin from ancient bones for carbon-14 dating may improve the accuracy of the dating procedure because gelatin is not likely to be contaminated by extraneous carbon.

Poultry

Composition of turkey meat. III. Essential amino acid composition.

SCOTT, M. L. (Cornell Univ., Ithaca, N. Y.). *J. Am. Dietetic Assoc. 35*, 247–9 (1959).

The essential amino acid compn. of male and female turkey breast and leg meats was detd. The results show that turkey protein is similar in amino acid compn. to that of chicken, beef, and pork when the amino acids are expressed as percentages of the proteins in these meats. Turkey meat, therefore, contains more of each essential amino acid because it contains more protein.

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Starch

Pointers on cooking of starch. Part I.

WHITE, T. A. (Natl. Starch and Chemical Corp.). *Food Proc. 20*, 45; 52 (May 1959).

A discussion of equipment, temp., time of gelatinization, pH, cooling and agitating conditions and other processing variables which should be kept in mind in food processes involving the thickening property of any starch.

Taste Testing

Exploratory physicochemical studies on the sense of taste.

LAWRENCE, A. R. AND FERGUSON, L. N. (Howard Univ., Washington, D. C.). *Nature 183*, 1469-71 (1959).

This study investigated the correlation of the molecular properties of taste substances to the physiological response. Two approaches were taken: examn. of mechanism by which the sapid substance can trigger a nerve impulse to the brain and discovery of the molecular properties responsible for characteristic tastes.

PERSONNEL

D. H. Rest

Mr. David H. Rest has been appointed Director of the Food Radiation Preservation Division, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago. Mr. Rest, who was associate director of the division, is responsible for the direction of the Institute's program for research and development on the application of ionizing radiations for the preservation of foods.

He first served on the Institute's staff from 1948 to 1955 as chief of the Engineering Division, leaving this post to become, for a brief period, Chief Engineer at Mt. Sinai Hospital in Chicago. He rejoined the staff of the Institute in 1956 as chemical engineer in the Office of the Deputy for Radiation. Among many other responsibilities, he has worked on the planning of the proposed Army Ionizing Radiation Center at Stockton, California.

Mr. Rest received a degree in chemical engineering from Armour Institute of Technology (now Illinois Institute of Technology) in 1947. He is a member of the Institute of Food Technologists, the American Chemical Society, and the American Institute of Chemical Engineering.

Col. J. P. Littlejohn

In making the announcement of the new appointment, **Colonel James P. Littlejohn,** Institute Commandant, called attention to the continued interest in radiation preservation research, both in the U.S.A. and outside our borders. Although the basic problems in this field have proved to be somewhat more difficult than was foreseen, research is being pursued with the confidence that the findings will eventually be translated into the language of processes and technologies. Mr. Rest's background and experience give assurance that all leads in this direction will be fully exploited. For the present the urgent task seems to be one of analyzing and consolidating the research gains.

FOOD COMPANY EXECUTIVES MEET AT COLUMBIA UNIVERSITY'S ARDEN HOUSE: Left to right are Hoke S. Simpson, Director of The Executive Program in Business Administration of Columbia University, Earl H. Kees, Marketing Manager of Flour and Pet Foods, General Mills, Inc., and James R. Gilbert, Assistant Treasurer of The Nestle Company. The Fourteenth Session of the Executive Program was held from June 15-July 25. Now in its eighth year, The Executive Program, part of the Graduate School of Business, is a six-week course of study for senior executives representing diverse industries.

The election of two new members to the Board of Trustees of Cornell University was announced today by Deane W. Malott, president of the University. They are Harold C. Hanover, president of the New York State AFL-CIO, representing

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labor; and **Dr. Catherine J. Personius,** professor of food and nutrition at Cornell, representing the faculty. Miss Personius is head of the Department of Food and Nutrition in the New York State College of Home Economics at Cornell, is coordinator of research in the college, and is also assistant director of the Agricultural Experiment Station at the University. At Cornell she has served on the Committee on University Policy and on the Board of Editors of the Cornell University Press.

A Department of Food Processing and Utilization in the University of Hawaii was authorized by action of the 1959 territorial legislature—the last session as a U. S. Territory. Funds for the department are provided in the University budget, thereby opening several new positions. One of these, that of Food Technologist in the Hawaii Agricultural Experiment Stations, has been accepted by **Dr. Edward Ross.** Dr. Morton M. Rosenberg, Experiment Station director, has designated Dr. Ross as head of the new department. Dr. Ross, formerly Horticulturist and Professor of Horticulture, the State College of Washington, and in charge of the fruit and vegetable processing program for 12 years there, will assume his new duties in Hawaii on August 15, 1959. The staff of the new department in Hawaii will pursue an active program of basic research in food science related to the utilization of tropical produce, both plant and animal. As soon as a strong research and development program is under way, Dr. Ross anticipates the initiation of a teaching program in food science and utilization. He looks for rapid progress at the University in the field of tropical agriculture and increased world interest in the utilization of native foods of tropical areas. In May 1960 the IFT will hold in Hawaii a major conference on tropical fruits. Emphasis on basic research has been indicated for the new department by Director Rosenberg. This will likely be the pattern of emphasis at the University under the administration of the new president, Dr. Laurence Snyder, scientist and educator, and past president of the AAAS.

Dr. E. Ross

P. R. Lloyd

The appointment of **Prescott R. Lloyd** as assistant to the vice-president in charge of production of Pacific Hawaiian Products Company, manufacturers of Hawaiian Punch, was announced today by Reuben P. Hughes, president. Mr. Lloyd was formerly technical sales consultant, California & Hawaiian Sugar Refining Corporation, Ltd. and before that acting manager food technology division of Stanford Research Institute. Previously he was associated with Libby, McNeill & Libby, National Canners Association and H. J. Heinz Corporation.

I. B. Kapp

In attendance at the International Congress held in Grasse, France, July 22-25, was **Ira B. Kapp,** Technical Director of the Felton Chemical Co., Brooklyn. Accompanied by Mr. Leon Gefen, of the company's Versailles branch, Mr. Kapp will review the meeting's major discussion points on his return. Perfume and essential oil producers attend the Congress on special invitation.

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Allied Chemical Corporation (National Aniline Division).....19
American Food Laboratories, Inc.....12
American Molasses Company.....35

Blumenthal Bros. Chocolate Company..23

Cadillac Employment Agency.....40
Continental Can Company Technical Section 530B

Dairyland Food Laboratories, Inc. 40
Distillation Products Industries.....14 and 15
Dodge & Olcott, Inc. Technical Section 480A
Durkee Famous Foods.....25

Fisher Scientific....Technical Section 492A
Firmenich, Inc. 32
Florasynth Laboratories, Inc. Technical Section 480B
Food and Drug Research Laboratories, Inc. 40
Food Materials Corporation Technical Section 518A
The Foxboro Company 27
Fries & Fries, Inc.....26
Fritzsche Brothers, Inc.....37

Givaudan Flavors, Inc.....11
The Griffith Laboratories, Inc.....29

Hoffmann-La Roche, Inc. Technical Section 536A
The Hubinger Company Technical Section 486A

Kelco Company.....17
Klenzade Products, Inc. 18
Knickerbocker Mills Company.....38
H. Kohnstamm & Co., Inc..... 5

LaWall & Harrisson.....40

Magnus, Mabee & Reynard, Inc.....24
Manton Gaulin Mfg. Co., Inc.....33
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Revlon, Inc.....16

C. G. Sargent's Sons Corp.....31
Schwarz Laboratories, Inc. 40
Scientific Associates.....40
A. E. Staley Mfg. Co.....36
Sterwin Chemicals, Inc. Technical Section 492B
Sunkist Growers..... 2

S. Twitchell Company.....21

Ungerer & Company, Inc. Technical Section 536B
Union Carbide Chemicals Co..... 1
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AVAILABLE: Food Technologist with M.S. degree in Microbiology and Chemistry. Extensive experience in quality control, research and production. Desires management position with progressive company in product development, technical service, or production. REPLY BOX 711, Institute of Food Technologist, 176 W. Adams St., Chicago 3, Ill.

POSITION WANTED: Tech. Sales/Mkt. Development. B.S., 13 years Sales, Market Development, Market Research and Sales Administration experience. Good knowledge food field plus drug, cosmetic, detergent, chemical specialties and related industries. Interested responsible position utilizing this background. Employed, available reasonable notice. REPLY BOX 694, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Food Technologist with extensive experience in Quality Control and Product Development of salad dressing products, fruits, vegetables, dog food, citrus beverages, and sausage products. REPLY BOX 708, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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WANTED: Man with B.S. or M.S. with good background in Organic Chemistry and Food Technology for work in flavor chemistry, flavor compounding and development. Salary dependent on qualifications. REPLY BOX 707, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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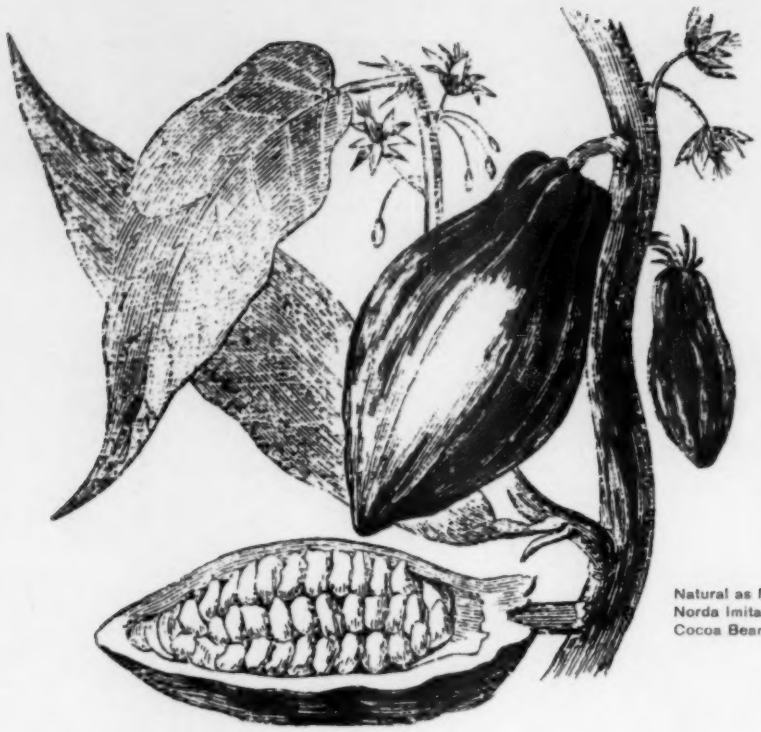

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